Homework 2 (EAS 8803: OBS. SEISMOLOGY - SPRING SEMESTER 2019)
Undergraduate Only Total points: 100. Due 03/05/2019

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: 12, 16, 20, 24, and 32 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 (20 points):
http://geophysics.eas.gatech.edu/classes/ObsSeis/misc/RESP.BK.PKD..HHZ
The original data (counts) in SAC format can be downloaded from the following website:
http://geophysics.eas.gatech.edu/classes/ObsSeis/misc/BK.PKD.HHZ.SAC

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

(a) Verify that the Stage 0 (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). The evalresp command can be downloaded from https://ds.iris.edu/ds/nodes/dmc/software/downloads/evalresp/

(c) Please 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 (You can either write your own code or use SAC's transfer function) (10 point).

5. Please select the magnitude 4.4 earthquake occurred in Eastern Tennessee, and download all waveforms (10 min before and 60 min after event time) within 5 degrees from IRIS DMC (http://ds.iris.edu/wilber3/find_stations/10984221). Then perform the following analysis (either within SAC or by your own program) (30 point)

   (a) Shift the reference time in the data so that its zero time corresponds to the origin time of this event (see related tutorial at http://geophysics.eas.gatech.edu/classes/SAC/). (5 point)

   (b) Plot the record section of the raw vertical component data versus epicentral distances. If you have too many waveforms, you can randomly select 30-50 waveforms to plot. You can use Matlab, SAC or 'pssac' command in GMT (see the SAC tutorial for more details). Try to mark prominent phases such as P, S, and surface waves (10 point)

   (c) Select one station that is the further away from the mainshock, but still has reasonable good signal to noise ratio. Remove the instrument response first into displacement. Then rotate it into radial and transverse component. Plot the rotated transverse, radial and vertical data. Identify the Love and Rayleigh waves. (5 point)

   (d) Please apply a 5-Hz high-pass filter to the vertical-component of the nearest station, take an envelope function, smooth it and then take a log-based-10 to obtain a smoothed-envelope function. Please identify/pick aftershocks following the mainshock, and compare with the known events listed in the ANSS catalog (http://www.quake.geo.berkeley.edu/anss/catalog-search.html). Comment on what you have found out. (10 point)

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/