Geo647- Lab 5
Seismic processing with matlab

We will begin with some introductory processing using Matlab software. Matlab is a set of mathematical tools that can handle a wide variety of problems. A simple seismic processing toolkit has been written by M.D. Sacchi (http://rubble.phys.ualberta.ca/~sacchi/SEISMIC_LAB/)

You should turn in a lab write-up that explains clearly what you did and what the results were. Figures and illustrations are good, as is doing it on some sort of word processing software. It should include an introduction explaining why and what we are doing. Neatness, clarity, punctuation, and spelling count. Matlab figures can be exported into a word document as illustrations or you can use "crtl Print Screen' to save the existing desktop into the clipboard and pasted into a word document.

We need to install the SeismicLab package to the D: drive. Download the file SeismicLab.tar.gz to the D: drive. Doubleclick on the file and extract the files to a directory named SeismicLab in D:. We now need to change one file. Click down to SeismicLab/DEMOS/setpath.m and open using wordpad.

Change from:
path(path, '/Users/sacchi/SeismicLab/MAIN')
path(path, '/Users/sacchi/SeismicLab/DEMOS')
path(path, '/Users/sacchi/SeismicLab/SEGY')

to:
path(path, 'D:/SeismicLab/MAIN')
path(path, 'D:/SeismicLab/DEMOS')
path(path, 'D:/SeismicLab/SEGY')

(or wherever you put the SeismicLab directory).
and save.

Brief Matlab tutorial (feel free to skip if you are comfoertable with matlab).
Now we need to start Matlab. Go to Start, programs, matlab. You should see several windows open. The window with the ">>" is the command window. Now type:
1 + 1
You should get an answer.

Now try:
x=1
y=1
x+y
z = sqrt(x+y)

try the help command.

Now try:
for i = 1:10
x(i) = i^2 + 10;
end
What is in x?
The "^2" means squared and the semicolon prevents it from echoing the command back.
X(i) has created a vector consisting of 10 elements.
Try "plot(x)" You should see a plot of the values of x.

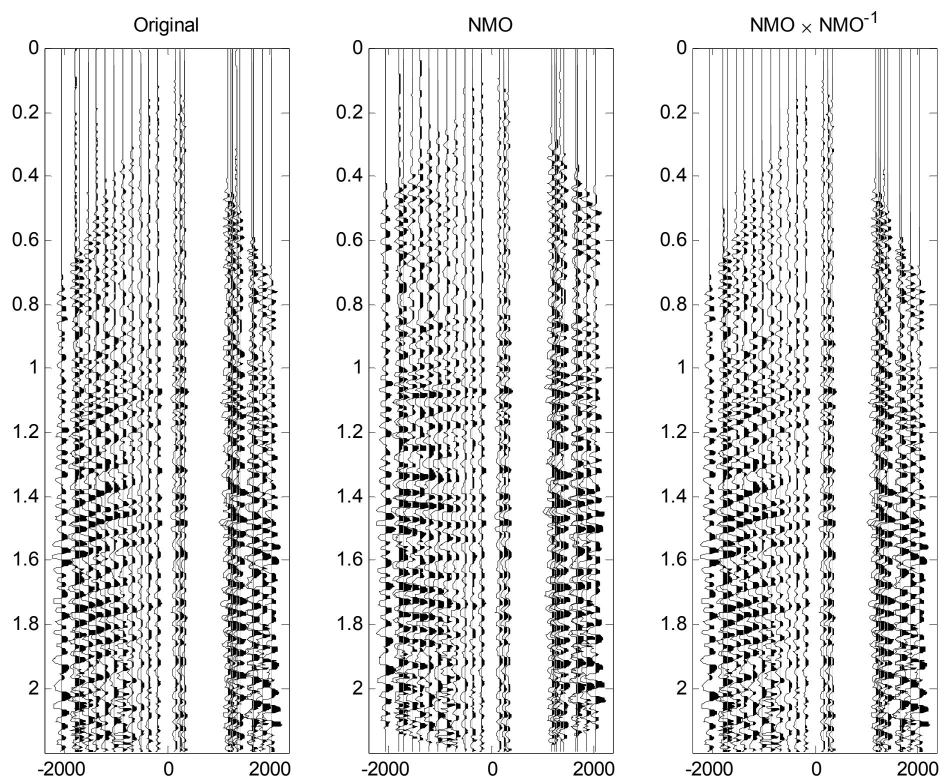
Now go to the File (under Matlab) and new. This should open a blank window.
Type in (or cut and paste) the same commands

```
for i = 1:10
    x(i) = i^2 + 10;
end
plot(x)
```

save as test1.m
Now type test1 in the command window. It should make the same plot as before.

Setting up for seismic analysis
In matlab
>>cd d:\Seismiclab\DEMOS
>> setpath

Velocity analysis
Now type "example_nmo"
You should see three CDP gathers labeled original, NMO and NMOxNMO^{-1}.
What are these?
Identify the direct waves and the reflections – it should look something like this:



Now go to file/open (under matlab) and open the example_nmo script. Look at it. First it reads in the data, then reads in the offset and calculates dt. It sets velocity (v) to 3600 and applies it to the data (D) using the function cvnmo. Finally, it plots the data.

Go to file and save as HWvel.m Type HWvel in the command line. You should get the same answer as before. Now change the line
"v = 3600" to "v = 3000"
"D3 = cvnmo(D2,offset,dt,v,-1); " to "D3 = cvnmo(D1,offset,dt,v,1)"

Add a new line "v =4000" before the D3 line.
Save and run. What do you see? Experiment with various velocities. Change the title on the output plots.

Questions:

What is the velocity of the upper layer?
Does one velocity flatten out all reflections at all times?

Filtering

Now save your script as HWvel.m and add the next 4 lines before the line that plots the figure. This filters the data. The 'butter' command calculates a set of filter coefficients and puts them in B and A. The filter command applies them to the data and creates new data, here named Dhf and Dlf. The 'high' means a highpass filter of order 3 – the higher the order the "stronger" the filter – unfortunately, a high order also does other stuff to the data. The 0.5 means the cutoff is at 0.5 of the Nyquist frequency (remember the Nyquist frequency is half the sample rate).

```
order = 3;
cutoff = 0.5;
[B,A] = butter(order,cutoff,'high')
Dhf = filter(B,A,D1);
order = 3;
cutoff = 0.5;
[B,A] = butter(order,cutoff,'low')
Dlf = filter(B,A,D1);
```

Change the plotting part to use the new data.

```
figure(1);clf,subplot(131);wigb(D1,0.9,offset,t);title('Original')
        subplot(132);wigb(Dhf,0.9,offset,t);title('highpass')
        subplot(133);wigb(Dlf,0.9,offset,t);title('lowpass')
```

<u>Questions</u>:

Try different filters (i.e. change the cutoff frequency to 0.25 or 0.75)
What is the difference between a highpass and a lowpass filter?
Assume that dt is in seconds – what is the Nyquist frequency (ie the hghest possible frequency) in this data set?
What filters brings out the deeper reflections best?
Draw a plot (response versus frequency) of a lowpass and highpass filter.

Chirps and convolution

Type clf (to clear the screen) and create a new m file with

```
% chirp
t = 0:0.1:1.0;
w = chirp(t);
plot(w);
```

This shows a chirp signal, which is used as a source in the vibroseis method. Now we will create a set of reflection coefficients representing the response of the earth (each non-zero number represents an interface defined by two acoustic impedances). The spacing between the zeros represent the time it takes to cross the layer. Then we convolve the chirp with the reflection coefficient to produce a synthetic seismogram (this is what would be recorded by the geophones). Finally, we cross-correlate (xcorr) the chirp to remove the chirps and see a more accurate representation of the seismogram.

```
% create a set of reflection coefficients
%
% first, make them all zero
```

```
%
for i = 600
    rc(i) = 0.0;
end
%
rc(250) = 0.8;
rc(300) = 0.35;
rc(320) = 0.45;
rc(500) = 0.4;
%
plot(rc)
%
seismogram = conv(w,rc);
plot(seismogram)
```

The % symbol means that this is a comment and is ignored by Matlab but is useful for remembering what you are doing.

Now add

```
tmp = xcorr(w,seismogram)
for i = 1:600
   decon(i) = tmp(601-i);
end
%
clf;
subplot(3,1,1), plot(rc)
subplot(3,1,2), plot(seismogram);
subplot(3,1,3), plot(decon(1:600));
```

Questions:
What type of seismic data uses a chirp?
Why would removal of the chirp signal as done in the last exercise be useful?