For this lab, break up into 2 groups. The lab assignment is due on Feb. 15.

**Crust and Upper Mantle Structure**

The purpose of this assignment is to learn how to analyze and interpret seismic refraction data and to use a two-dimensional ray tracing program. The data are from a modern controlled source experiment in the northwestern Basin and Range province. The data are from an IRIS-PASSCAL seismic experiment conducted in northwestern Nevada in 1986. We have provided you with the record sections from the four shot points 8, 9, 10 and 11, which constitute a north-south profile. The attached paper (Benz, Smith, and Mooney, 1990) describes the experiment and shows a map of the shotpoint and sensor locations.

**Objectives**--To recognize waveform characteristics of seismograms from propagation through crustal structure and to determine the travel-times of phases and effects. To do this you will pick the travel times from scanned seismograms using a MatLab script then model the phases for crust and upper-mantle structure using a 2-D ray tracing program. Crustal phases of interest are $P_{\text{dir}}$, $P_g$, $P_n$, $P_mP$, and $P_cP$. These phases are associated with 1st-order velocity discontinuities.

**Experiment Specifications:** The data were recorded on 1 sec period, vertical seismometers with station spacings of ~ 1 km. The sources were 0.5 to 1 Kton shots in 30 m boreholes. The vertical seismometers and borehole shots preclude good S-wave transmissions, although some can be noted.

We will model the crustal structure using a sophisticated ray tracer called RayGui written by Uri Ten Brink of the USGS. The program is loaded on a Linux machine (rbsl3.gg.utah.edu) in WBB 706.

The data will first be interpreted from the large scale record sections that I handed out, then you can use the scanned images for digitizing the picks.

I especially want you to get a feel of the characters of the seismograms, frequency of waveforms, character of the first arrivals, etc. I also want you to get a feel for the uniqueness of your models and how systematic and random errors effect the interpretations.

Be a sport, do not look at the models in the paper.

Steps:
1. a. Identify all correlatable phases on the large scale record sections by connecting each pick with straight or curved lines directly on the record section to make up a travel time branch.

    b. Digitize the travel times which must be corrected for the reducing velocity. Determine the individual first and latter arrivals to the nearest 0.1 sec and estimate the standard error for each picked time. The standard error is needed as input to an inversion of these types of data. Note that you must pick the beginning of the phase not necessarily the maximum phase.

    c. Estimate the dominant frequency of each phase and how it changes with distance.

    d. For either of the true amplitude seismograms, plot the corresponding amplitudes in units of mm for both a refracted and a reflected phase and comment on their differences.


    a. For the group assignments, first determine the 1-D crustal structure by fitting the travel times for the phases assuming a flat layered structure, i.e., MacRay 1D. See the example “SP3” already loaded in MacRay 1D.

    b. For the next part bring the corresponding data sets together, SP 8-11 and SP 9-10 and input your combined travel times and determine a 2-D crustal structure using RayGui.

3. General questions to answer for the lab:

    a. For each pair of students turn in your 1-D and 2-D models including the corresponding traveltime curve and picks.

    b. Using the average picking errors for each branch, how much error is there in the depth determinations and velocities for your 1-D models. You can do this qualitatively by perturbing your models by the timing error, RMS, starting at the first layer, then moving down each layer.

    c. How important was it to constrain the models using the wide-angle reflections.

    d. How does frequency vary with distance for the first arrivals. Be specific for each branch.
e. Plot the ray path coverage (x vs. z) of each identified branches for the 2-D model by plotting out the ray path diagrams. How much of the crust does your model really cover.