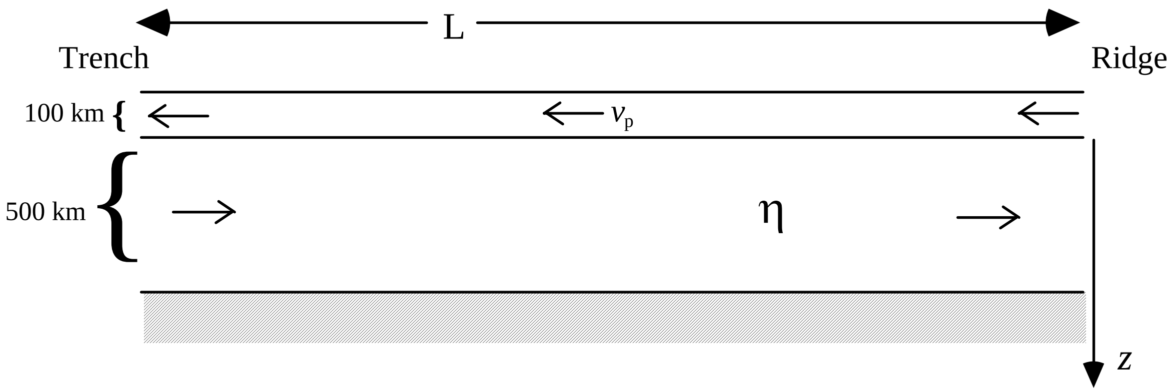
12.520 Problem Set 8 **Due 12/11/06**

1) We can deduce some interesting results about mantle viscosity and global return flow from some simple 1-D models. Assume that plates are 100 km thick. Below the plates a low viscosity layer extends to 600 km depth, below which the mantle is assumed rigid.

Model I: Oceanic Plate



An oceanic plate moves from ridge to trench with velocity *v*. The plate has length L, the asthenosphere viscosity is η.

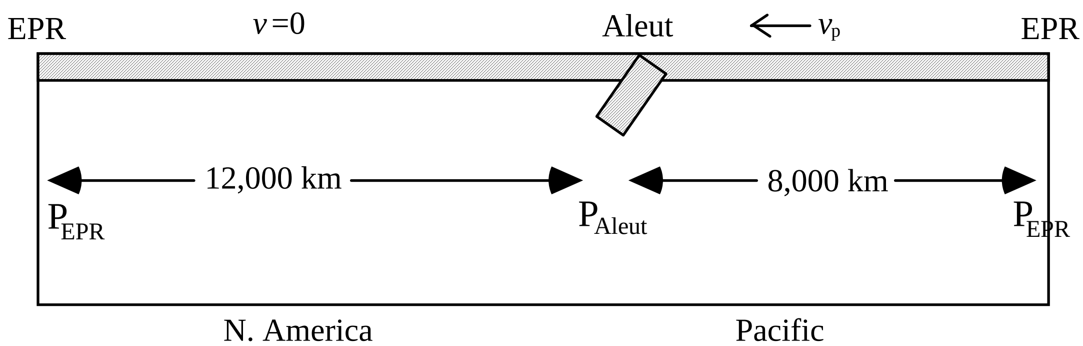
There are two components to the flow in the asthenosphere (assumed 1 dimensional). The first is the flow dragged by the plate v_c (for Couette flow). Write an expression for v_c as a function of *z*, the depth below the base of the plate.

The second flow component v_R (Poiselle flow) results from the return flow of material from trench to ridge, sufficient to transport a flux of $100 km \cdot v_P$, plus any material dragged in, back to the ridge. Write an expression for v_R as a function of *z*, and for $V_T(z) = V_R(z) + V_c(z)$.

What is the total pressure drop from trench to ridge? What topographic surface expression would it have? Using a reasonable upper bound to this topography of 1 km, find an upper bound for η. How does this compare to one estimate from postglacial rebound of 10^{21} Pas?

Model II:

The real world is more complicated. In particular, because of the 3-D nature of plate geometry, more than one path exists from any given trench back to a ridge. For example, material subducting in the Aleutian arc can return to the East Pacific Rise beneath the Pacific Plate (L = 8,000 km) or beneath the N. American plate (L = 12,000 km). The pressure drop is the same either way. An idealized geometry is:



Write an expression and make a plot for the total flow velocity $v_T(z)$ underneath the Pacific and N. American plates. (Remember, under the Pacific, $V_T = V_c + V_R$; under N. America, $V_T = V_R$; all material arriving at the trench must return to the ridge.) Compare the results of the flow under the Pacific for Model I and Model II (include a plot of V(z) for both cases).