Environmental Fluid Dynamics – MEEN 7710
Spring 2011 – Due March 3
Homework #6:

1. Consider the Laminar Ekman layer above a Rigid Surface:

The following simplified momentum equations:

$$-fv = \frac{-1}{\rho}\frac{\partial p}{\partial x} + \nu\frac{d^2u}{dz^2}$$

$$fu = \frac{-1}{\rho}\frac{\partial p}{\partial y} + \nu\frac{d^2v}{dz^2}$$

can be further simplified by expressing pressure gradients in terms of Geostrophic velocity components as:

$$-f\left(v - V_g\right) = \nu\frac{d^2}{dz^2}\left(u - U_g\right) \qquad (1)$$

$$f\left(u - U_g\right) = \nu\frac{d^2}{dz^2}\left(v - V_g\right) \qquad (2)$$

Assuming U_g and V_g are height independent, solve Equations 1 and 2 subject to the following boundary conditions:

$$u = 0 \qquad v = 0 \qquad \text{at} \qquad z = 0$$
$$u \to U_g \qquad v \to V_g \qquad \text{as} \qquad z \to \infty$$

For the final solution, have the *x*-axis oriented with the Geostrophic wind vector (i.e., $U_g = G$ and $V_g = 0$. Plot your solution as a hodograph and as vertical velocity profiles of *u* and *v*. The solution should be: where *a* is the inverse of the Ekman Depth.

$$u = G\left[1 - e^{-az}\cos(az)\right]$$

$$v = Ge^{-az}\sin(az)$$

2. Please explain the phenomena of Eckman pumping.
3. Solve problems 1,2 and 3 from Ch.14 of Kundu.