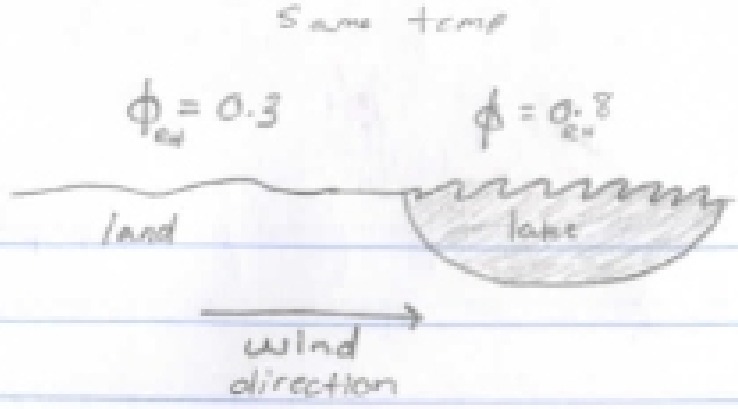
7/16



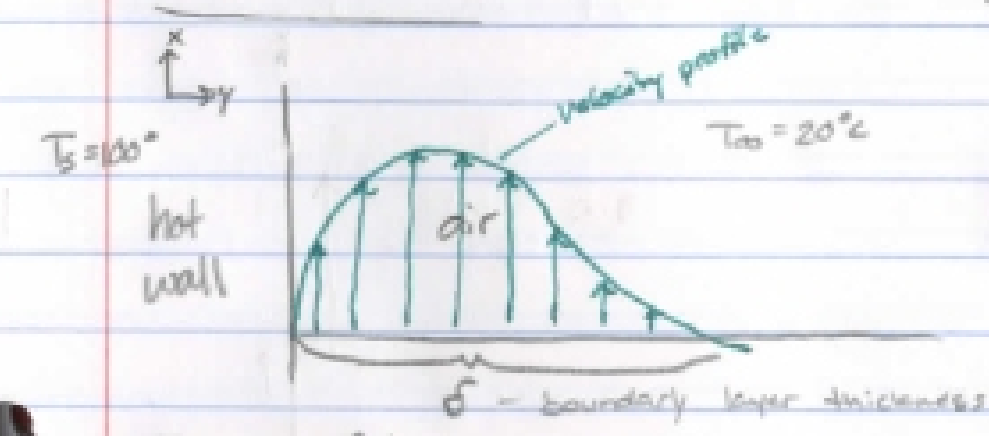
Free Convection is buoyancy driven, or $\Delta \rho$

$$Gr = \frac{g\beta(T_s - T_\infty)L^3}{\nu^2} \qquad \beta = -\frac{1}{\rho}\frac{d\rho}{dT}$$

$$Pr = \frac{c_p \mu}{k} = \frac{\nu}{\alpha}$$

$$Ra = Gr\, Pr = \frac{g\beta(T_s - T_\infty)L^3}{\nu\alpha}$$

Flat Plate



$$T^* = \frac{T - T_\infty}{T_s - T_\infty}$$

$$\overline{Nu} = \frac{\bar{h}L}{k} = \frac{4}{3}\left(\frac{Gr_L}{4}\right)^{1/4} g(Pr)$$

Example 9.1

$x = L = .25\,m$

$T_s = 70°C = 343\,K$

$T_\infty = 25°C = 298\,K$

$$\beta = -\frac{1}{\rho}\left(\frac{d\rho}{dT}\right)_p \qquad \beta_{ig} = \frac{1}{T} \rightarrow \text{in kelvin}$$

$$T_{Avg} = \frac{T_s + T_\infty}{2} = \frac{70+25}{2} = 47.5 \approx 320\,k \longrightarrow \beta = \frac{1}{320}$$

$$Gr_{0.25} = \frac{(9.81\,m/s^2)\left(\frac{1}{320\,k}\right)(343k - 298k)(.25m)^3}{\left(17\times10^{-6}\,m^2/s\right)^2}$$

$$Gr_{0.25} = 7.45\times10^7$$

$\nu_{@320} = 17\times10^{-6}\,m^2/s$

$k_{@320} = 0.028\,W/m°C$

$Pr_{@320} = .705$

$$Ra = Gr\, Pr = (7.45\times10^7)(.705) = 5.26\times10^7$$

$$\delta_L = \frac{6L}{\left(\frac{Gr}{4}\right)^{1/4}} = \frac{6(.25)}{\left(\frac{7.45\times10^7}{4}\right)^{1/4}} = 0.0228\,m$$

$$U = \frac{2\nu(T^*)Gr_L^{1/2}}{L} = \frac{2(17\times10^{-6}\,m^2/s)(.28)(7.45\times10^7)^{1/2}}{.025} \longrightarrow U = 0.32\,m/s$$