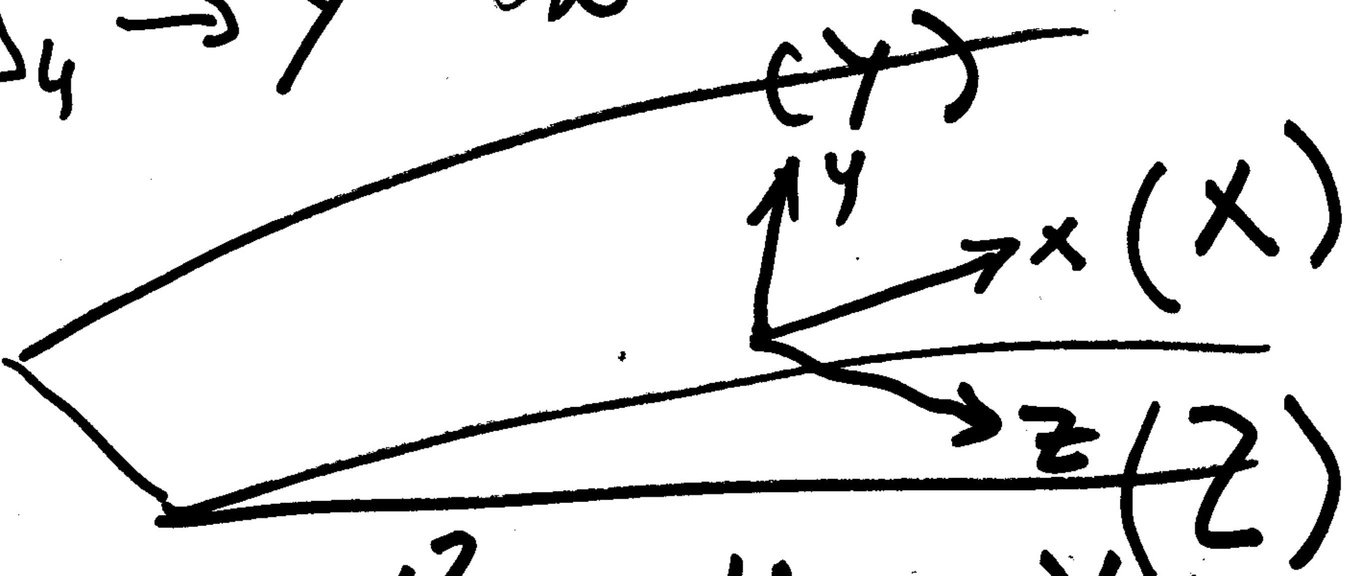
Prof. MW Date. Lec-12-13

$$\frac{d\Delta_u}{dx} = F\left[U_\infty, \frac{dU_\infty}{dx}, \nu, \Delta_u, P_r\right]$$

$$\Delta_u \rightarrow Y \qquad U_\infty \Rightarrow \frac{X}{t} \qquad \frac{dU_\infty}{dx} = \frac{1}{t}$$

$$\frac{\tau_w}{\rho} = \nu \left.\frac{\partial u}{\partial y}\right|_0$$



$$\frac{\mu}{\rho} = \nu = \frac{Y^2}{t} \qquad \frac{d\Delta_u}{dx} \rightarrow \frac{Y}{X}$$

$$St_x = \frac{h_x}{\rho c_p u_\infty}$$

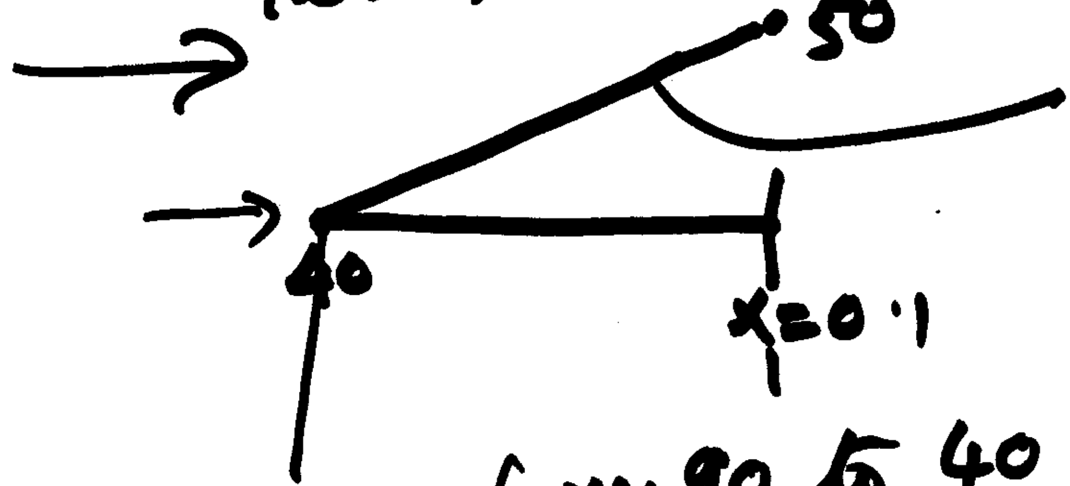
$$= \frac{q_w}{\rho c_p u_\infty (T_w - T_\infty)}$$

$$= \frac{-k \partial T/\partial y|_0}{\rho c_p u_\infty (T_w - T_\infty)}$$

$$= -\frac{\alpha\, \partial T/\partial y|_0}{u_\infty (T_w - T_\infty)}$$

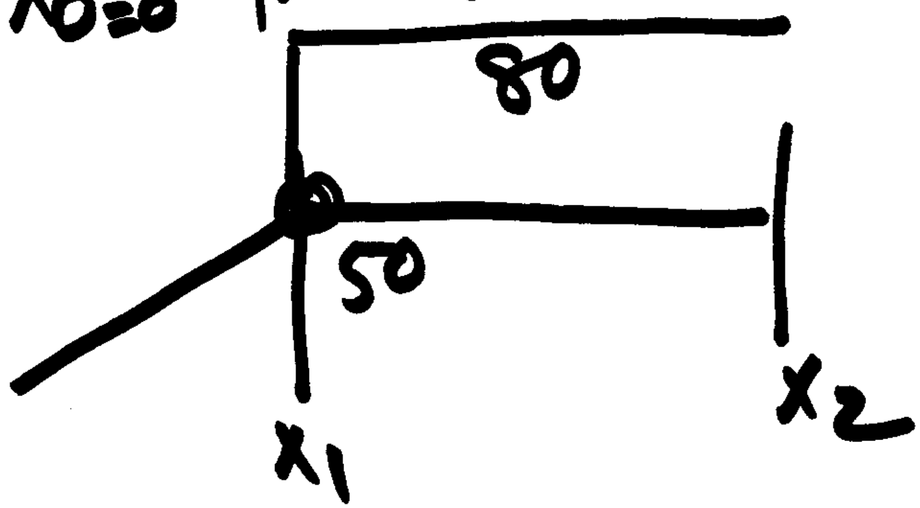
$$= \frac{3}{2} \frac{\alpha}{u_\infty \Delta}$$

$T_\infty = 90$

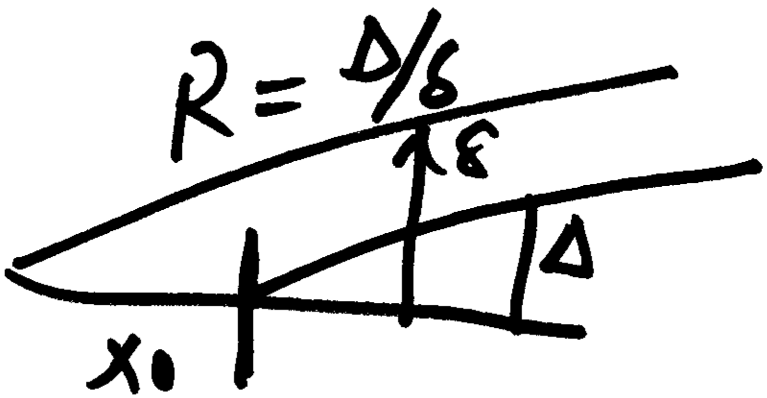


$\dfrac{dT_w}{dx_0} = 10\ldots$

from 90 to 40



$80-90$
$-(50-90)$
$= 80-50$



$R = 0$
$x = x_0$

$$\frac{d\Delta_2}{dx} = St\,x$$

$$= \frac{3}{10}\,\delta R \frac{dR}{dx} + \frac{3}{20} R^2 \frac{d\delta}{dx} = \frac{3}{2}$$

$$= \frac{3}{10}\sqrt{\frac{280}{13}\frac{\nu x}{u_\infty}}\, R \frac{dR}{dx}$$

$$+ \frac{3}{20} R^2 \cdot \frac{140}{13}\frac{\nu}{u_\infty} \cdot \sqrt{\frac{13}{280}\cdot\frac{u_\infty}{\nu x}}$$

$$= \frac{3}{2}\frac{\kappa}{\Delta u_\infty}$$

$$R^3 + 4R^2 x \frac{dR}{dx} = \frac{13}{14}\frac{1}{Pr}$$

$$\frac{4}{3} x^{.25} \frac{d}{dx}\left[x^{.75} R^3\right] = \frac{13}{14\,Pr}$$

$$\frac{T-T_\infty}{T_w-T_\infty} = 1-\frac{T_w-T}{T_w-T_\infty}$$

$$\Delta_2 = \int_0^\delta \left[\frac{3}{2}\eta - \frac{1}{2}\eta^3\right]\left[1-\frac{3}{2}\eta_T + \frac{1}{2}\eta_T^3\right] * dy$$

$$\delta_2 = \int_0^\delta \frac{u}{u_\infty}\left(1-\frac{u}{u_\infty}\right)dy$$

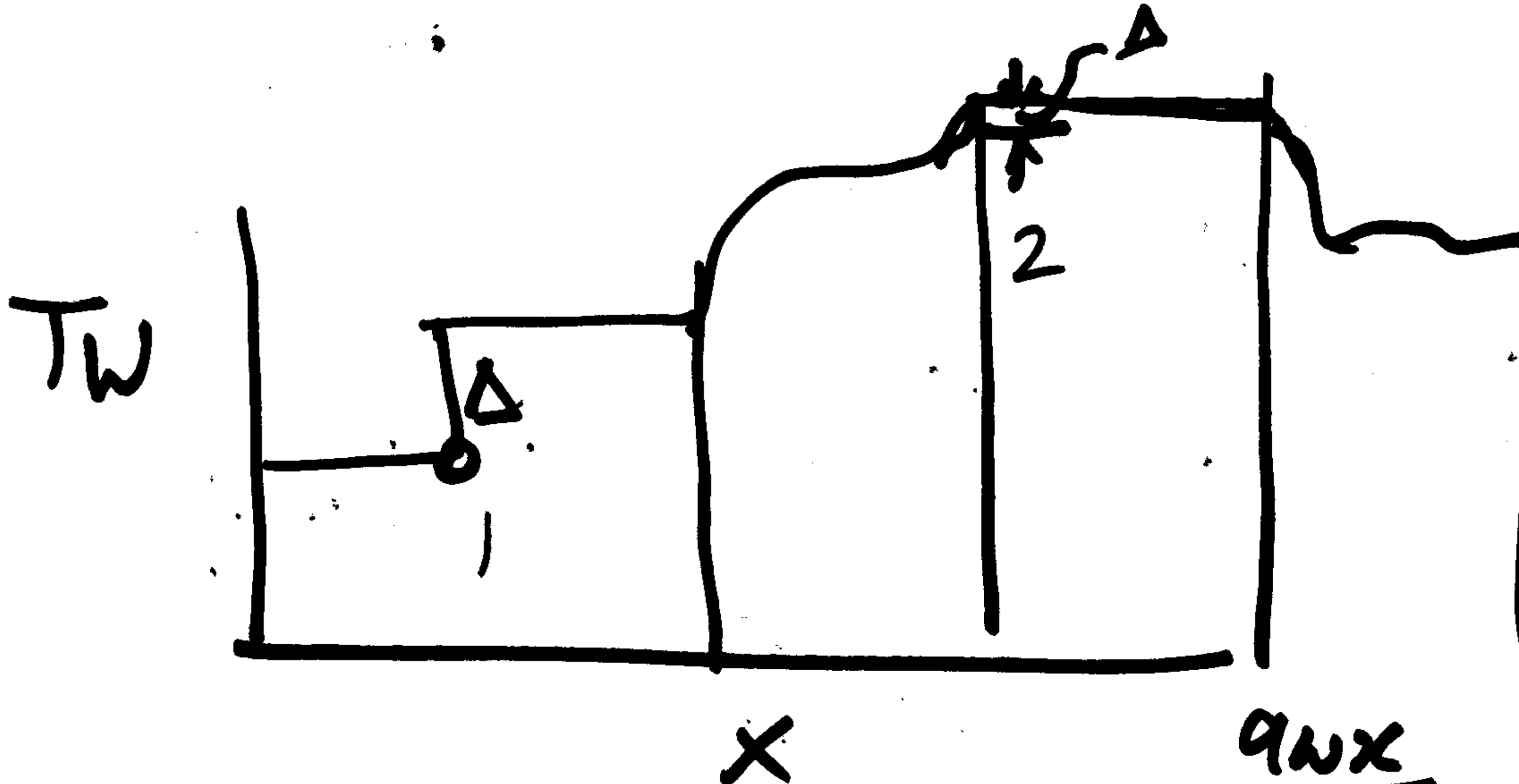
$$= \int_0^\delta \left[\frac{3}{2}\eta - \frac{1}{2}\eta^3\right]\left[1-\frac{3}{2}\eta + \frac{1}{2}\eta^3\right]$$

$$\boxed{\frac{\delta_2}{\delta} = \frac{39}{280}}$$

$$\tau_w = \mu \cdot \frac{\partial u}{\partial y}\Big|_0$$

$$= \mu \cdot u_\infty \cdot \frac{3}{2} \cdot \frac{1}{\delta}$$

$$\frac{\tau_w}{\rho V_\infty^2} = \frac{3}{2} \cdot \frac{\nu}{u_\infty \delta}$$

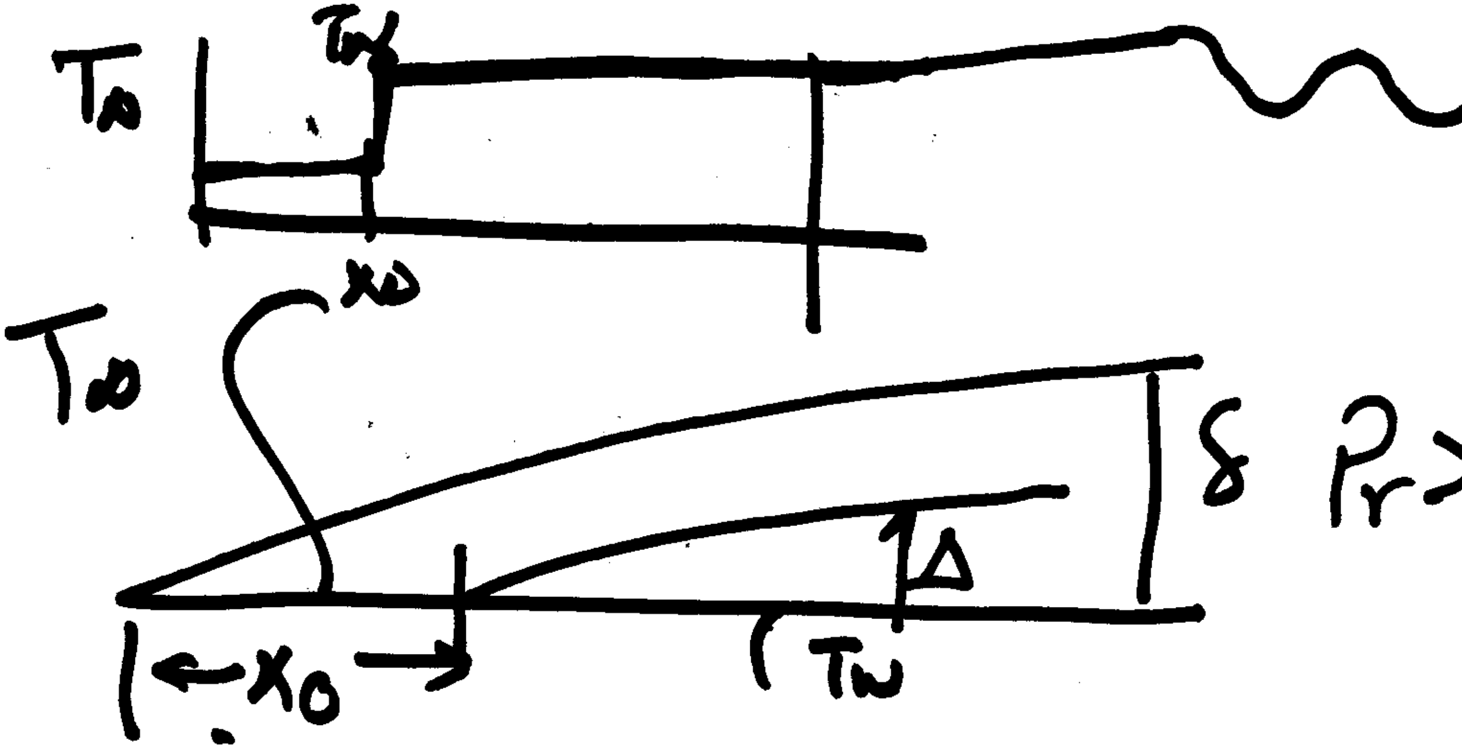


$$q_w = -k \frac{\partial T}{\partial y}\Big|_0$$

$$h(x, x_0) = \frac{q_{wx}}{(T_w - T_\infty)}$$

$$= -k \frac{\partial \theta}{\partial y}\Big|_{y=}$$

$$\theta = \frac{T_w - T}{T_w - T_\infty}$$



$Pr > 1$

$$\theta = \frac{T_w - T}{T_w - T_\infty}$$

$$\theta(x, y, x_0)$$

$$T - T_\infty = [1 - \theta(x, y, x_0)](T_w - T_\infty)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\frac{\partial^2 T}{\partial y^2}+\frac{\nu}{c_p}\left(\frac{\partial u}{\partial y}\right)^2$$

$T=T_1$ is a soln

$T=T_2$ is a soln

$T=c_1 T_1+c_2 T_2-\ldots$

$$F(K_T) = a - b K_T \qquad \frac{m}{c_1}$$

$$\frac{U_\infty}{\nu}\frac{d\Delta u^2}{dx} = a - b\left(\frac{\Delta u^2}{\nu}\frac{dU_\infty}{dx}\right)$$

$$a = \frac{1-x^0}{q^2} = \frac{1}{(.293)^2} = 11.67$$

$$b = \frac{a}{1/q^2} = 11.67(.493)^2$$

$$= \underline{\underline{2.87}}$$

$$\frac{\Delta_h^2}{\nu}\frac{du_\infty}{dx} = \left(\frac{k}{h_x}\right)^2 \cdot \frac{1}{\nu} \cdot m \cdot c x^{m-1}$$

$$= \left(\frac{k}{h_x}\right)^2 \frac{1}{\nu} \cdot \frac{mc}{x} \cdot c x^{m}$$

$$= \frac{\Delta_h^2}{\nu} \cdot \frac{mc}{x} \cdot c x^{m}$$

$$Nu_x Re_x^{-1/2} = C_1$$

$$\frac{h_x \cdot x}{k} \cdot \left(\frac{c x^{m+1}}{\nu}\right)^{-1/2} = C_1$$

$$\frac{x}{\Delta_h} \cdot \left(\frac{c x^{m+1}}{\nu}\right)^{-1/2} = C_1$$

$$\frac{x^2}{\Delta_h^2} \cdot \left(\frac{c x^{m+1}}{\nu}\right)^{-1} = C_1^2$$

$$\Delta_h^2 = \frac{x^2 \cdot c x^{m+1}}{\nu \, C_1^2} = \frac{x^2}{\Delta_h^2}$$

$$= \frac{Re_x \, x^{m+1} \cdot m \cdot c}{\nu \cdot q}$$

$$Re_x = \frac{u_\infty x}{\nu} = \frac{c x^{m+1}}{\nu}$$

$$\frac{U_\infty}{\nu}\frac{d\Delta_4^2}{dx} = F\left(\frac{\Delta_4^2}{\nu}\frac{du_0}{dx}\right)$$

$$\frac{Nu_x}{Re_x^{1/2}} = -\theta'(0) = G(m)$$

$$\frac{h_x \cdot x}{K} Re_x^{1/2} = \frac{x}{\Delta_4} Re_x^{1/2} = G(m)$$

$$\Delta_u = \frac{x\, Re_x^{1/2}}{G}$$

$$\frac{\Delta_u^2}{\nu}\frac{du_0}{dx} = \frac{x^2 \cdot Re_x}{\nu \cdot G} \cdot m \cdot C x^{m-1}$$

for fixed Pr

$$\frac{y}{x} = \underset{\substack{\downarrow \\ \delta_u}}{y^{a}} \underset{\substack{\downarrow \\ 1/u_\infty}}{\left(\frac{x}{t}\right)^{b}} \underset{\substack{\downarrow \\ \nu}}{\left(\frac{y^2}{t}\right)^{c}} \underset{\frac{du_\infty}{dx}}{\left(\frac{1}{t}\right)^{d}}$$

$$1 = a + 2c$$

$$-1 = b$$

$$0 = -b - c - d.$$

$$\frac{\Delta_u^2}{\nu}\frac{du_\infty}{dx} = K_T \qquad \frac{\delta_2^2}{\nu}\frac{du_\infty}{dx} = K$$

$$\frac{\delta^2}{\nu}\frac{du_\infty}{dx} = \lambda$$

$$\frac{d\Delta_2}{dx} + \frac{\Delta_2}{u_\infty}\frac{du_\infty}{dx} = St_x$$

$$\frac{d\delta_2}{dx} + \frac{\delta_2}{u_\infty}\frac{du_\infty}{dx}(2+H) = C_{fx}$$

$$H = \frac{\delta_1}{\delta_2}$$

$$\Delta_4 = \frac{K}{h_x} = \frac{W/m\text{-}K}{W/m^2\text{-}K} = (m)$$

$$St_x = \frac{h_x}{\rho c_p u_\infty} = \frac{K}{\rho c_p \Delta_4 u_\infty} = \frac{\alpha}{\Delta_4 u_\infty}$$

$$St_x = \frac{3}{2} \cdot \frac{\alpha}{\left(\frac{13}{14}Pr\left[1-\left(\frac{\xi}{x}\right)^{.75}\right]\right)^{1/3} \cdot 4.67\sqrt{\frac{\nu x}{U_\infty}} \cdot U_\infty}$$

$$=$$

$$\frac{d\delta_2}{dx} = \frac{\tau_w}{\rho u_\infty^2}$$

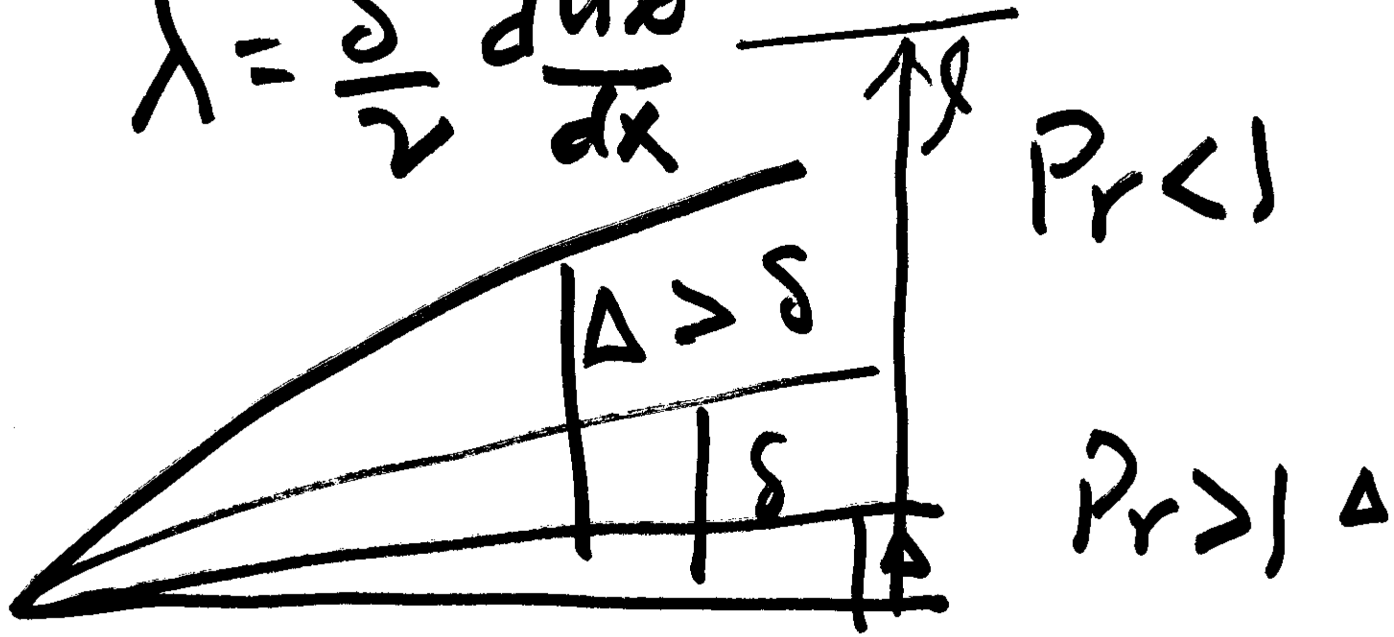
$$\frac{39}{280}\frac{d\delta}{dx} = \frac{3}{2}\frac{\nu}{u_\infty \delta}$$

$$\delta \cdot \frac{d\delta}{dx} = \frac{140}{13} \cdot \frac{\nu}{u_\infty}$$

$$\frac{d\delta^2}{dx} = \frac{280}{13}\frac{\nu}{u_\infty}$$

$$\delta^2 - 0 = \frac{280}{13}\frac{\nu x}{u_\infty}$$

$$\lambda = \frac{\delta^2}{2}\frac{dU_0}{dx}$$



$l \geq \Delta$ Pr<1

$\geq \delta$ Pr>1