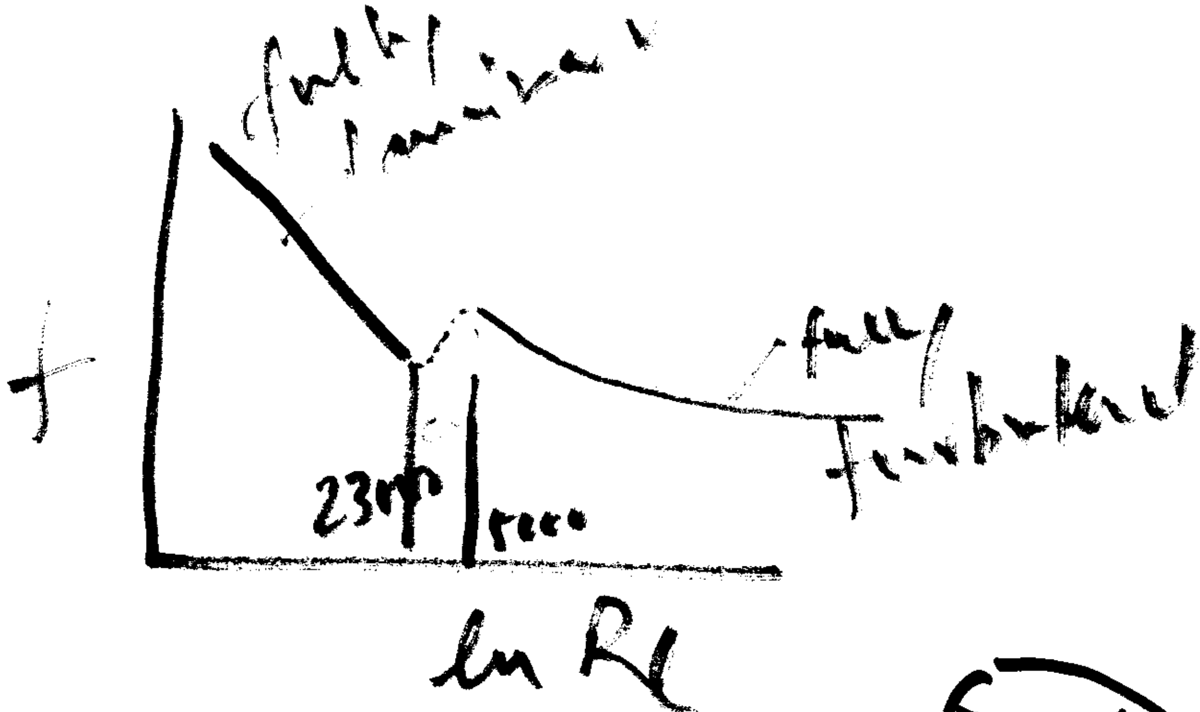
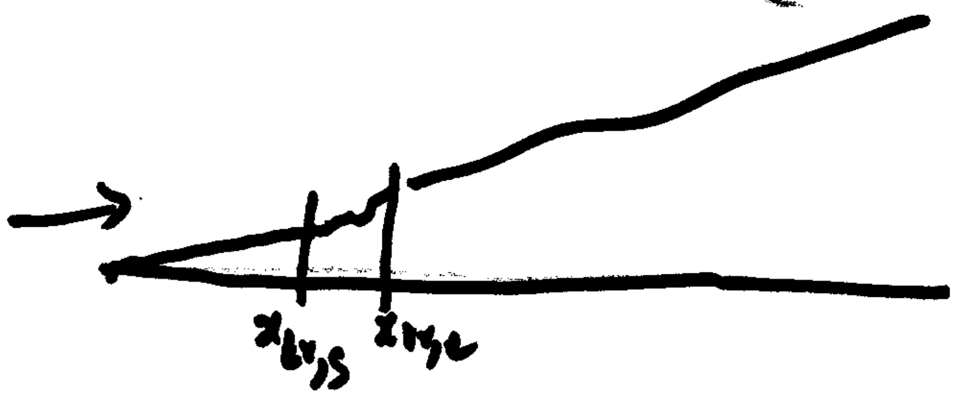
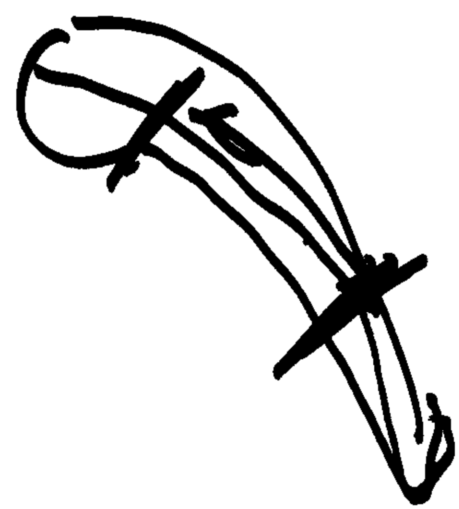
Prof. A.W. Date
Lec. No. 28 & 28
Date - 11/3/11

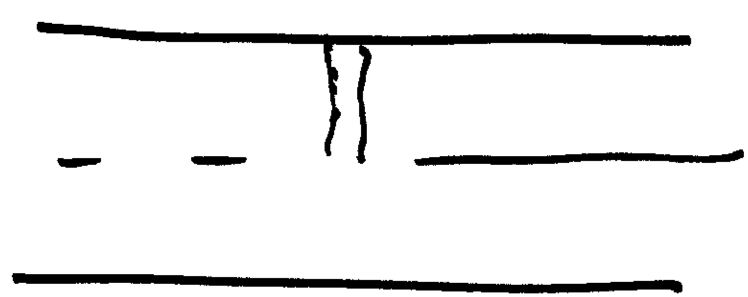


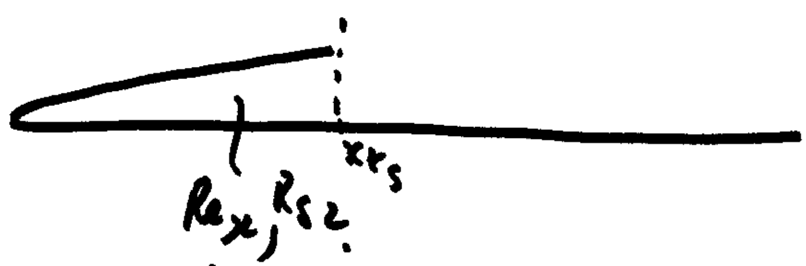


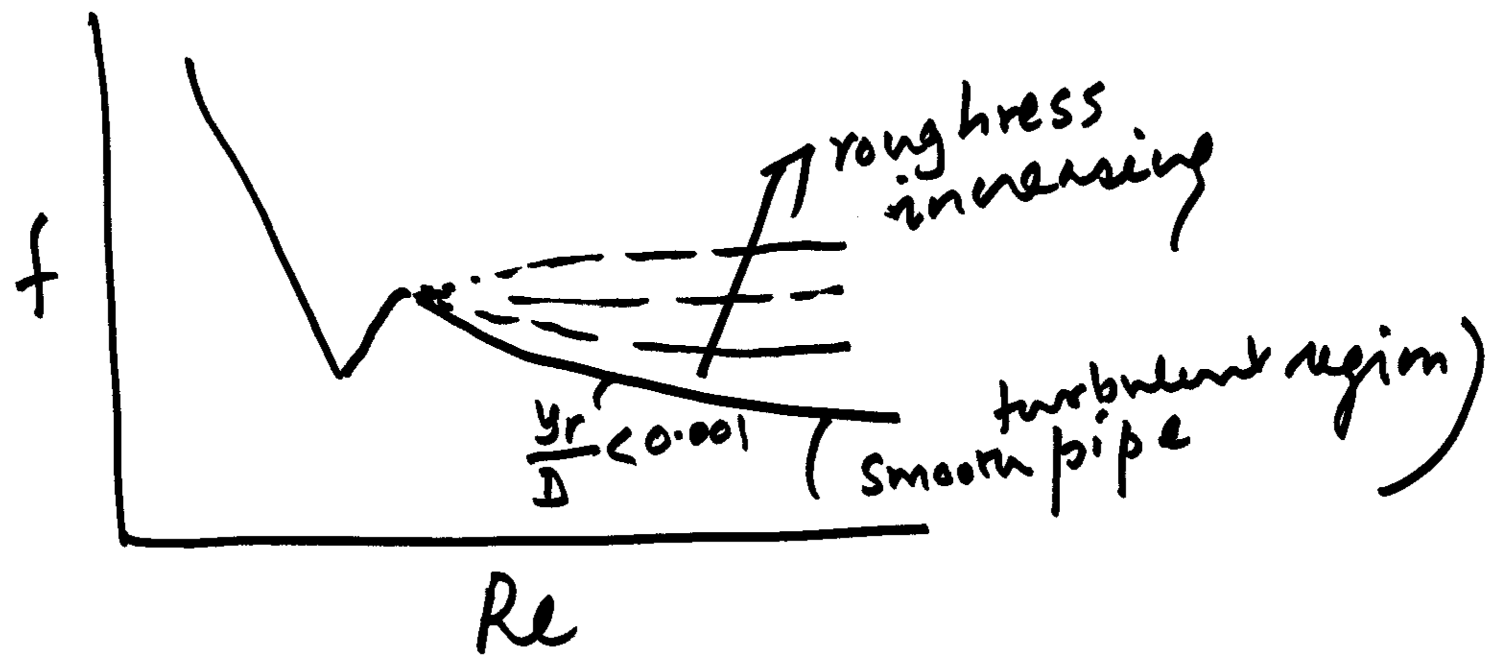


$$0 < \gamma = \frac{1}{N}\sum_{k=1}^{N}\frac{\Delta t_{t,k}}{\Delta t} < 1$$

= Intermittancy






f
Re
roughness increasing
$\frac{yr}{D} < 0.001$
turbulent region
(smooth pipe)

LSL

$$\frac{\dot{q_w}}{\rho c_p} = -\alpha \frac{\partial T}{\partial y}$$

$$T - T_w = -\frac{q_w y}{\rho c_p \alpha}$$

$$-\frac{(T - T_w)}{q_w / (\rho c_p u_\tau)} = \frac{y}{\alpha} \cdot u_\tau$$

$$T^+ = \left(\frac{y}{\nu} u_\tau\right) \frac{\nu}{\alpha}$$

$$= y^+ \cdot P_r \quad \text{— LSL}$$

$$T^+ = \frac{1}{K_t} \ln y^+ + C_T(P_r) \quad \text{(TL)}$$

$$T^+ = \sigma \left(u^+ + PF\right)$$

$$T^+ = \frac{1}{\kappa_t} \ln y^+ + C_T(Pr)$$

$$u^+ = \frac{1}{\kappa} \ln y^+ + 5.4$$

$$T^+ = \left(\frac{\kappa}{\kappa_t}\right) (u^+ - 5.4) + C_T(Pr)$$

$$= \frac{\kappa}{\kappa_t} \left(u^+ + \underbrace{\left(\frac{C_T(Pr)}{(\kappa/\kappa_t)} - 5.4 \right) \frac{\kappa}{\kappa_t}}_{PF} \right)$$

σ

$$= \sigma \, (u^+ + PF)$$

LSL

$$T^+ = Pr \, y^+ = Pr \, u^+$$

$$= Pr \, (u^+ + 0)$$

$$\frac{1}{\sigma} = Pr$$

$$q_w = -k\frac{\partial T}{\partial y} = -(k+k_t)\frac{\partial T}{\partial y}$$

$$\frac{\tau_w}{\rho} = \mu_{eff}\frac{\partial u}{\partial y} = \left(\frac{\mu+\mu_t}{\rho}\right)\frac{\partial u}{\partial y}$$

$$\frac{q_w}{\rho c_p \tau_w} = \frac{-(k+k_t)}{\mu+\mu_t}\cdot\frac{\partial T}{\partial y}\Big/\frac{\partial u}{\partial y}$$

$$= -(k+k_t)$$

$$\frac{q_w}{\tau_w/\rho} = \frac{-(k+k_t)\rho}{(\mu+\mu_t)}\cdot\frac{\partial T}{\partial y}\cdot\frac{1}{\partial u/\partial y}$$

$$\frac{q_w}{u_\tau^2} = -\frac{(k+k_t)}{\nu+\nu_t}\cdot\frac{\partial T/\partial y}{\partial u/\partial y}$$

$$\frac{q_w}{\rho c_p u_\tau^2} = -\frac{(\alpha+\alpha_t)}{\nu+\nu_t}\cdot\frac{\partial T}{\partial y}\Big/\frac{\partial u}{\partial y}$$

$$\frac{1}{u_\tau}\cdot\frac{\partial u}{\partial y} = \left(-\frac{\partial T/\partial y}{q_w/\rho c_p u_\tau}\right)\cdot\frac{(\alpha+\alpha_t)}{\nu+\nu_t}$$

$$\frac{\partial u^+}{\partial y} = \frac{1}{Pr_{eff}}\cdot\frac{\partial T^+}{\partial y}$$

$$\boxed{\frac{\partial T^+}{\partial u^+} = Pr_{eff}}$$

$$\tau_w = (\mu + \mu_t)\frac{\partial u}{\partial y}$$

$$\frac{\tau_w}{\rho} = u_\tau^2 = (\nu + \nu_t)\frac{\partial u}{\partial y}$$

$$= \nu\left(1 + \frac{\nu_t}{\nu}\right)\frac{\partial u}{\partial y}$$

$$1 = \frac{\nu}{u_\tau^2}\cdot\frac{\partial u}{\partial y}\left(1 + \frac{\nu_t}{\nu}\right)$$

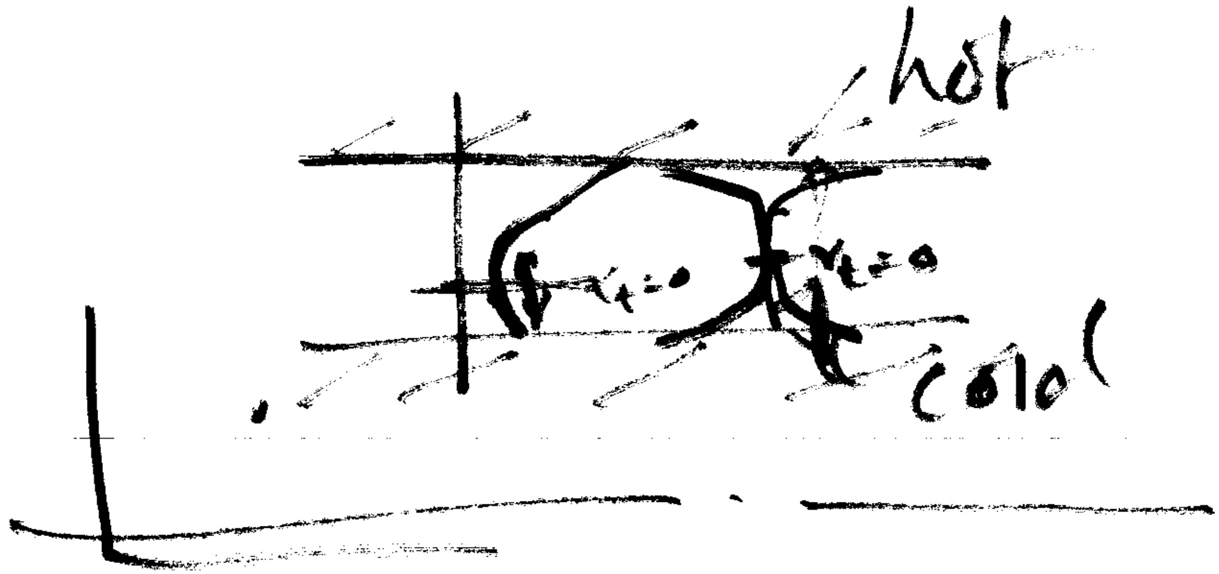
$$= \frac{\partial u^+}{\partial y}\left(1 + \frac{\nu_t}{\nu}\right)$$

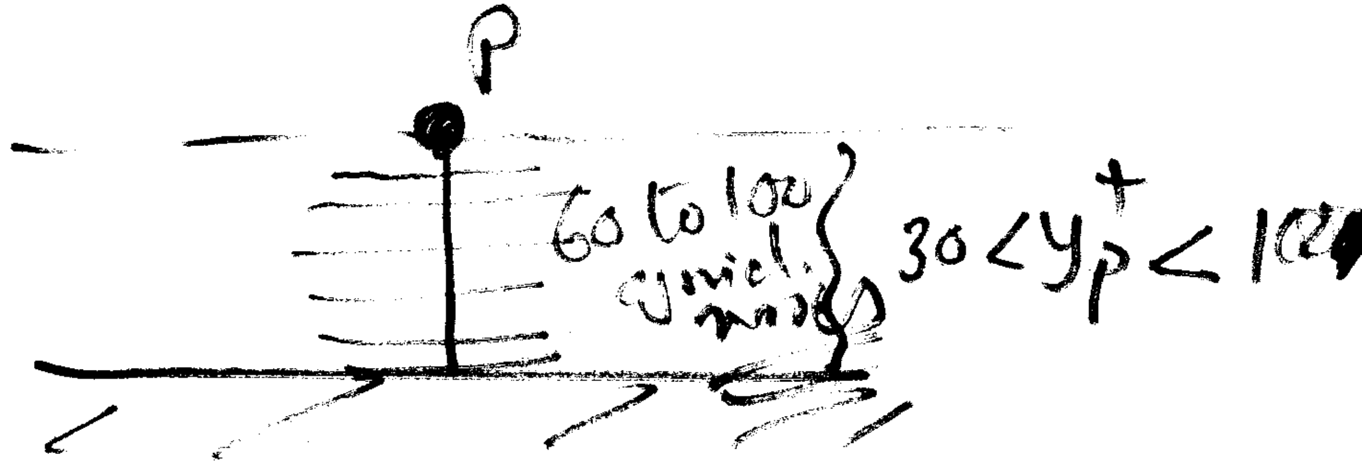
$$\therefore \boxed{\frac{\nu_t}{\nu} = \frac{1}{\frac{\partial u^+}{\partial y^+}} - 1}$$

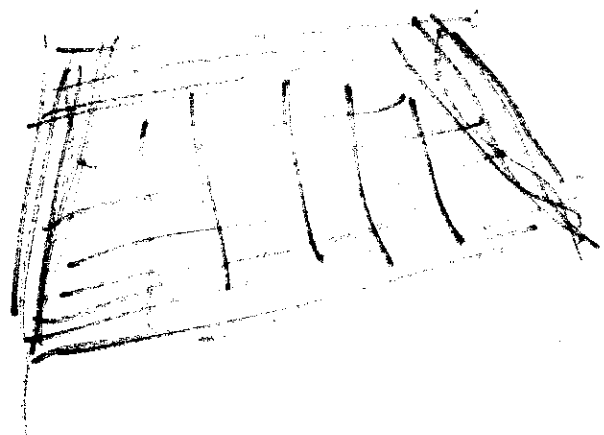
$$T^+ = \frac{-(T - T_w)\rho c_p u_\tau}{q_w}$$

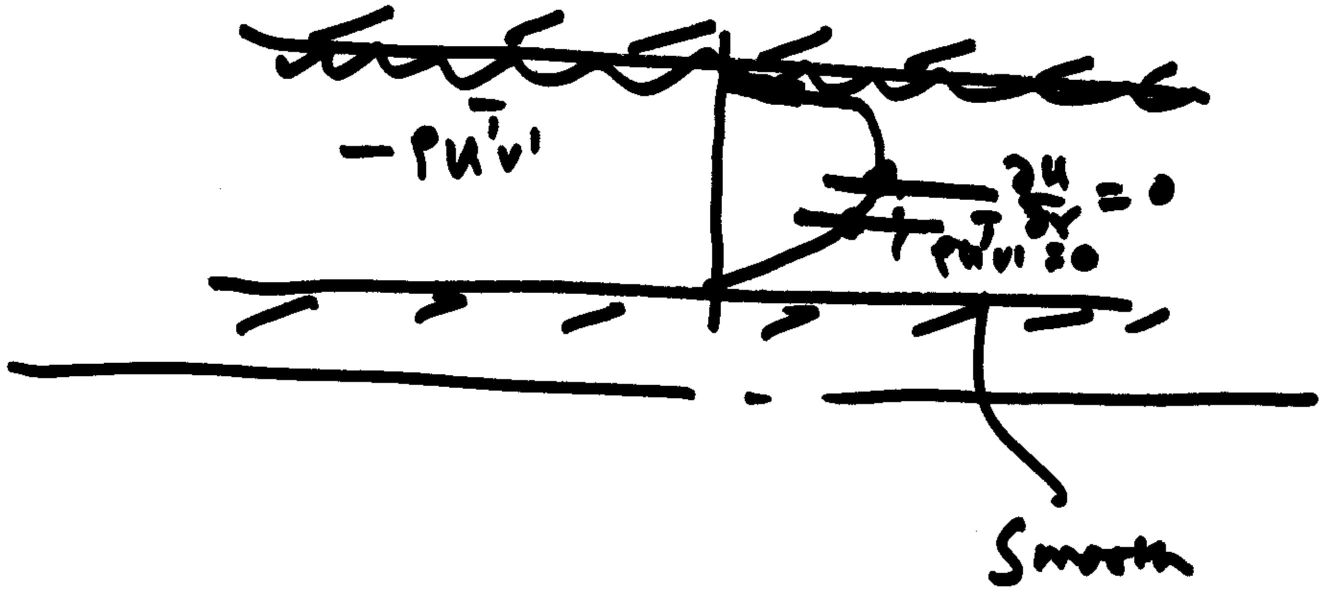
$$= \frac{(T_w - T)\rho c_p u_\tau}{q_w}$$

$$= \frac{\rho c_p u_\tau}{h_y}$$


hot
cold

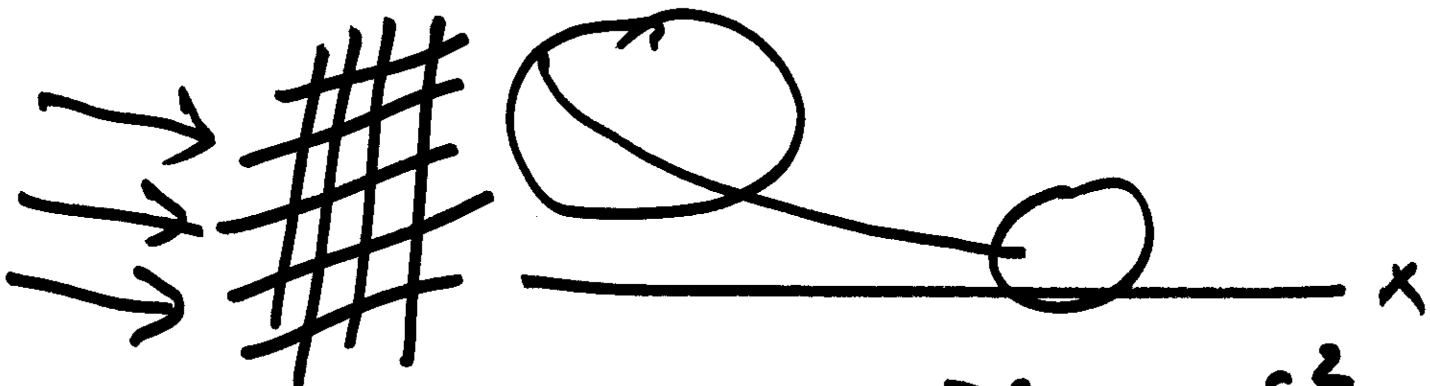

P
60 to 100
$30 < y_p^+ < 100$





$-\rho\overline{u'v'}$
$\frac{\partial u}{\partial y} = 0$
$\rho\overline{u'v'} = 0$
Smooth

$$\rho\varepsilon \propto \frac{v'^3}{L}$$



$$\frac{De}{Dt} = -\varepsilon \qquad \frac{D\varepsilon}{Dt} = -c_2 \frac{\varepsilon^2}{e}$$

$$e \propto t^{-n}$$

$$1 < n < 1.2$$

$$n \simeq 1.8$$