"Turbulent Pipe Flow"

$$\tau_{tub} = \tau_v + \tau_{eddy}$$

$$\tau_{tub} = \mu \frac{du}{dy} + \eta \frac{d\bar{u}}{dy}$$

η - eddy Viscosity

μ - dynamic Viscosity

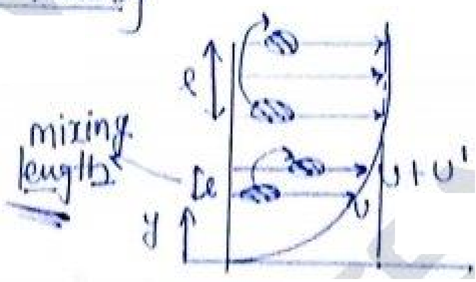
Kinematic eddy Viscosity

$$\boxed{\varepsilon = \frac{\eta}{\rho}}$$

<u>Reynold's theory</u>

$$\tau_e = \rho u' v'$$

<u>Prandtl's theory</u>



$$\frac{du}{dy} = \frac{(u+u') - u}{l}$$

$$u' = l \frac{du}{dy} = v'$$

$$\tau_e = \rho u' v' = \rho \left(l \frac{du}{dy} \right) \left(l \frac{du}{dy} \right)$$

Karman theory $\boxed{l \propto y \Rightarrow l = ky}$ k = Karman universal Const.

pipe flow $k = 0.4$

$$l = 0.4y$$

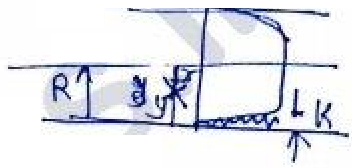
$$\Rightarrow \tau_0 = \rho l^2 \left(\frac{du}{dy}\right)^2$$

$$\Rightarrow \sqrt{\frac{\tau_0}{\rho}} = 0.4y\frac{du}{dy} = V_* = \text{Shear Velocity}$$

$$\int du = 2.5V_* \int \frac{dy}{y}$$

$$U = 2.5V_* \ln y + C$$

$$\boxed{U = 5.75V_* \log_{10}(y) + C}$$



Smooth pipe	Rough
$y = y'$, $U = 0$	$y = y'$, $U = 0$
$\frac{U}{V_*} = 5.5 + 5.75\log_{10}\left(\frac{V_* y}{\nu}\right)$	$\frac{U}{V_*} = 8.5 + 5.75\log_{10}\left(\frac{y}{k}\right)$
$y = R$, $U = U_{max}$	$y = R$, $U = U_{max}$
$U_m = \frac{2\int_0^R u r\,dr}{R^2}$	$\frac{U}{V_*} = 4.75 + 5.75\log_{10}\left(\frac{R}{k}\right)$

Now

$$V_{rms} = \sqrt{\frac{\bar{u}^2 + \bar{v}^2 + \bar{w}^2}{3}}$$

$$\text{Degree of turbulance} = \sqrt{\frac{\bar{u'}^2 + \bar{v'}^2 + \bar{w'}^2}{3}}$$

Mixing length :- (l) The average distance covered by bulk of molecules to aquire the new environment velocity.
(for new collission)