1

lecture 20

Nov 16, 2018

Assume $\frac{l_y}{l_y} \ll 1$

$Re \gg 1$

$$\bar{u}\frac{\partial \bar{u}}{\partial x} + \bar{v}\frac{\partial \bar{u}}{\partial y} = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x} - \frac{\partial \overline{u'v'}}{\partial y}$$

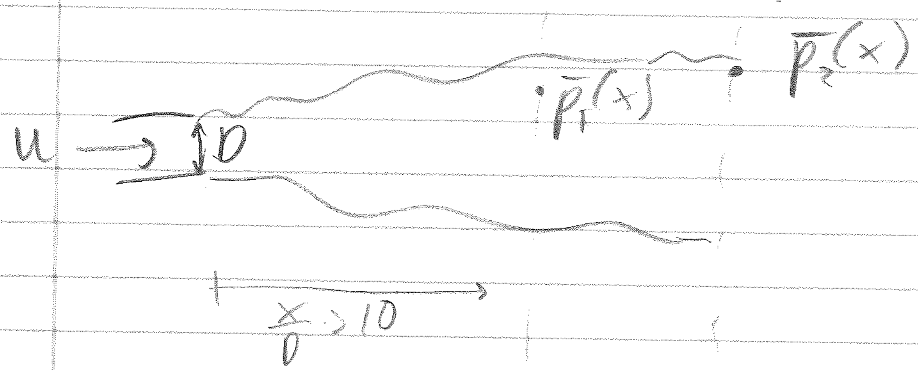
boundary layer equations

$$0 = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial y} \Rightarrow \bar{p} = \bar{p}(x)$$

→ jet, wakes, BLs

$$\frac{\partial \bar{u}}{\partial x} + \frac{\partial \bar{v}}{\partial y} = 0$$

$\bar{p}_1(x) = p_{atm}$; $\bar{p}_2(x) = p_{atm}$



$\bar{p} = p_{atm}$

jet $\bar{u}\frac{\partial \bar{u}}{\partial x} + \bar{v}\frac{\partial \bar{u}}{\partial y} = -\frac{\partial \overline{u'v'}}{\partial y}$

$$\frac{\partial \bar{u}}{\partial x} + \frac{\partial \bar{v}}{\partial y} = 0$$

1) incompressible, 2D, steady

2) thin $\frac{l_y}{l_x} \ll 1$

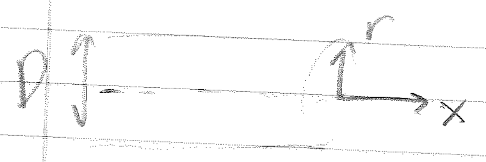
3) high Re $\frac{U l_y}{\nu} \gg 1$

4) $\frac{x}{D} > 10\text{-}20$

5) uniform ambient pressure

3 unknowns $(\bar{u}, \bar{v}, \overline{u'v'})$, 2 eqns

<u>Axisymmetric jet</u>



$l_y \to l_r$

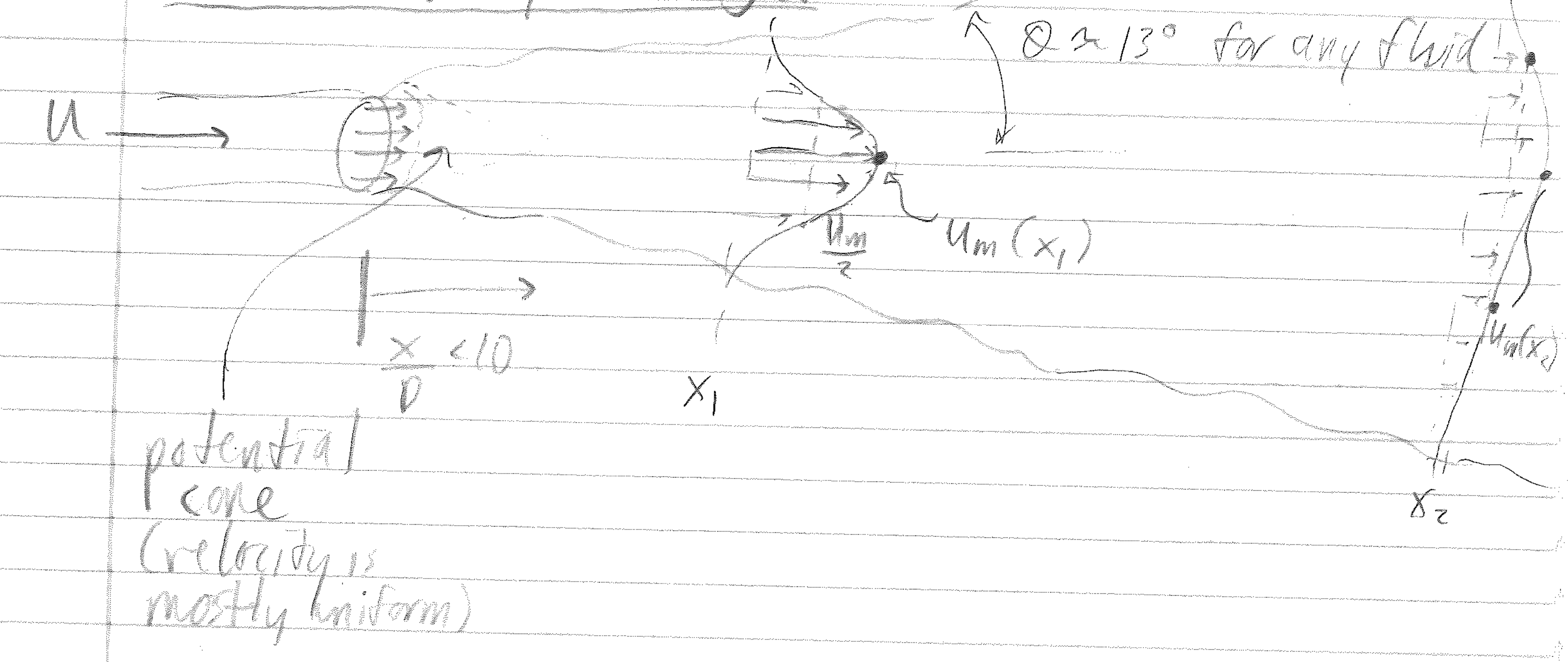
$\frac{l_r}{l_x} \ll 1$

$Re = \frac{U l_r}{\nu} \gg 1$

$$\bar{u}\frac{\partial \bar{u}}{\partial x} + \bar{v}\frac{\partial \bar{u}}{\partial r} = -\frac{1}{r}\frac{\partial}{\partial r}\left(r\,\overline{u'v'}\right)$$

$$\frac{\partial \bar{u}}{\partial x} + \frac{1}{r}\frac{\partial}{\partial r}\left(r\bar{v}\right) = 0$$

Turbulent axisymmetric jet

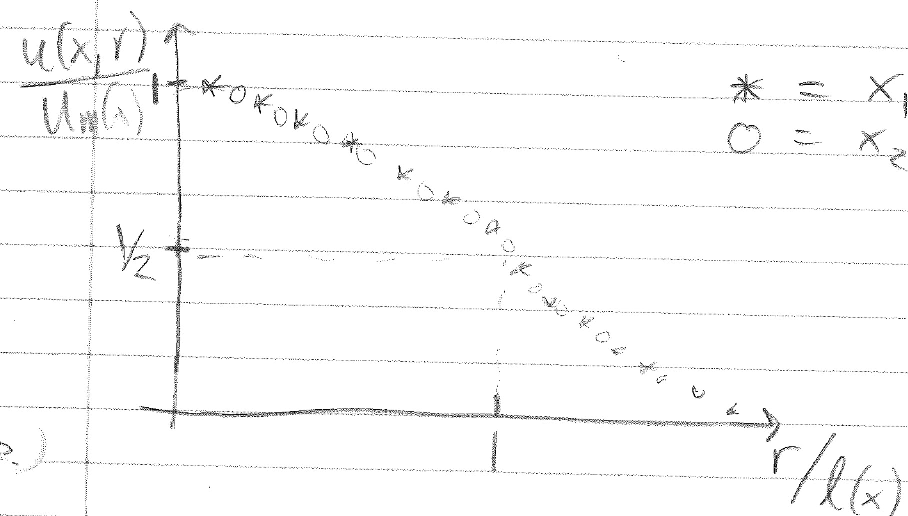


measure $\overline{u}(x,r)$

$U_m(x)$ = max velocity @ $r=0$

half width $\ell(x)$ as

$$\frac{\overline{u}(x,r)}{U_m(x)} = \frac{1}{2}$$



self similarity

$$\frac{\overline{u}(x,r)}{U_m(x)} = f\left(\frac{r}{\ell(x)}\right)$$