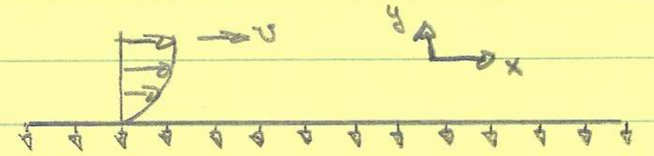
3.6 Asymptotic Suction Flows

3.61 Uniform Suction on a plane



$v = v_w < 0$

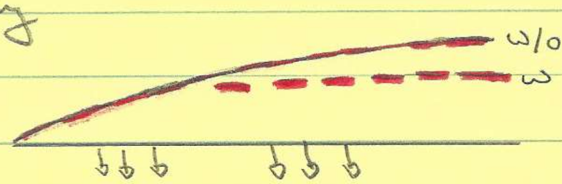
linear $\quad \rho v_w u_y = \mu u_{yy} \quad$ b.c.: $u = 0,\ y = 0$

since $v = v_w =$ constant $\quad\quad u = U,\ y = \infty$

$$\Rightarrow \quad u = U\left[1 - e^{(v_w y/\nu)}\right] \quad v = v_w$$

$\delta = -\dfrac{4.6\nu}{v_w}$ independent of x: convection & diffusion in balance

Practical application is for boundary layer control, especially to delay flow separation



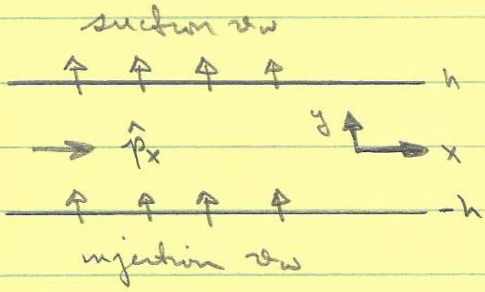
Strip Suction

3.62 Flow between plates with bottom injection and top suction

v_w = constant

$w = 0$

$u = u(y)$



$$\rho v_w u_y = -\hat{p}_x + \mu u_{yy}$$

$$u(\pm h) = 0$$

$$u/u_{max} = \frac{2}{Re}\left(y/h - 1 + \frac{e^{Re} - e^{Re\,y/h}}{\sinh Re} \right) \qquad Re = v_w h/\nu$$

$u_{max} \leftarrow h^2(-\hat{p}_x)/2\mu$: $u_{\mathcal{C}}$ for parabolic flow

$u/u_{max}\big|_{\text{small } Re}$ = parabolic flow

$u/u_{max}\big|_{\text{large } Re} = 2(1 + y/h)/Re$ Straight-line variation which suddenly drops to zero at the upper wall

* u_{ave} ↓ as Re ↑

ie C_f ↑ as v_w ↑

Solutions also possible for axial flow in circular annulus or flow between rotating cylinders

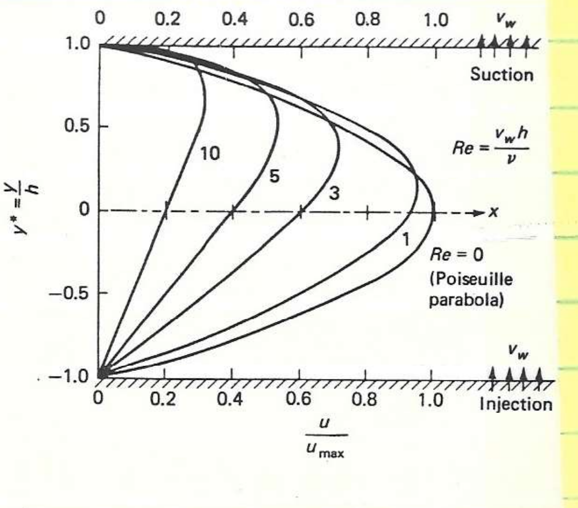


FIGURE 3-18
Velocity profiles for flow between parallel plates with equal and opposite porous walls, Eq. (3-127).