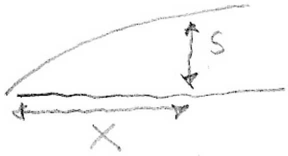
$\boxed{\text{EX 12}}$

$\boxed{1}$ $\boxed{X \ll \delta}$



$\boxed{2}$

$$\boxed{\begin{aligned} u(0) &= 0 \\ v(0) &= 0 \\ \lim_{y \to \infty} u &= U \end{aligned}}$$

$\boxed{3}$ APPROCHE
DE BLASIUS
SANS LE FACTEUR "2"

$$\boxed{\eta(x,y) = \frac{y}{\delta(x)} = \frac{y}{\sqrt{\frac{\nu x}{U}}}}$$

$$u = \frac{\partial \psi}{\partial y} = U \delta f' \underbrace{\frac{\partial \eta}{\partial y}}_{1/\delta} = U f'$$

$$v = -\frac{\partial \psi}{\partial x} = -U\left(\delta' f + \delta f' \underbrace{\frac{\partial \eta}{\partial x}}_{-\frac{y\delta'}{\delta^2} = -\eta\frac{\delta'}{\delta}}\right) = U \delta'(\eta f' - f)$$

$$\frac{\partial u}{\partial x} = -U f'' \eta \frac{\delta'}{\delta}$$

$$\frac{\partial u}{\partial y} = \frac{U f''}{\delta} \qquad \frac{\partial^2 u}{\partial y^2} = \frac{U f'''}{\delta^2}$$

$$\underbrace{u \frac{\partial u}{\partial x}}_{-U^2 \cancel{f' f'' \eta \frac{\delta'}{\delta}}} + \underbrace{v \frac{\partial u}{\partial y}}_{\cancel{U^2 \delta' \frac{\eta f' f''}{\delta}} - U^2 \frac{\delta' f f''}{\delta}} = \underbrace{\nu \frac{\partial^2 u}{\partial y^2}}_{\nu \frac{U f'''}{\delta^2}}$$

$$-U \overbrace{\delta \delta'}^{\frac{1}{2}\frac{\nu}{U}} f f'' = \nu f'''$$

$$\boxed{\begin{aligned} \delta(x) &= \sqrt{\frac{\nu x}{U}} \\ \delta'(x) &= \frac{1}{2}\sqrt{\frac{\nu}{x U}} \end{aligned}}$$

$$\boxed{2 f''' + f f'' = 0}$$

4

$$\boxed{2f''' + ff'' = 0}$$

1 ODE D'ORDRE 3

$g \triangleq f'$
$h \triangleq f''$

$$\left\{\begin{array}{l} h' = (fh)/2 \\ g' = h \\ f' = g \end{array}\right.$$

3 EDO D'ORDRE 1

$f(0) = 0$
$f'(0) = 0$ $\quad g(0) = 0$
$f''(0) = \underbrace{0.332}$ $\quad h(0) = 0,332$

A OBTENIR NUMERIQUEMENT PAR LA METHODE DU TIR (VOIR EPL 1104 !)

6

EAU
$\rho = 10^3 \ kg/m^3$
$\mu = 10^{-3} \ Ns/m^2$
$\nu = 10^{-6} \ m^2/s$

A SAVOIR :-)

5

COEFFICIENT FROTTEMENT LOCAL

$$C_f = \frac{\tau_w}{\rho U^2/2} = \frac{\mu U \overbrace{f''(0)}^{0,332}}{\underbrace{\delta}_{= \sqrt{\frac{\nu x}{U}}} \rho U^2/2} = \frac{0,664}{\sqrt{\frac{Ux}{\nu}}} = 0,664 \frac{1}{\sqrt{Re}}$$

COEFFICIENT FROTTEMENT GLOBAL

$$C_{f,m} = \frac{\int_0^x \tau_w}{\rho U^2 x/2} = 1,328 \frac{1}{\sqrt{Re}}$$

CAR $\frac{1}{x}\int_0^x \left(\frac{\nu x}{U}\right)^{-1/2} = 2\left(\frac{\nu x}{U}\right)^{-1/2}$:-)

si, si !!

7

$$C_{f,m} = \frac{1,328}{\underbrace{\sqrt{\frac{10 \ 1}{10^{-6}}}}_{Re = 10^7}} = 4,2 \ 10^{-4}$$

8 INSTABILITES TURBULENTES A PARTIR DE

$Re \simeq 54000$

C'EST PLUS VRAIMENT PERTINENT :-(