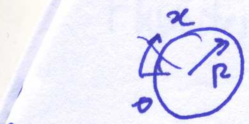
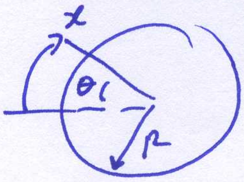
I



R, L, ρ

p_0

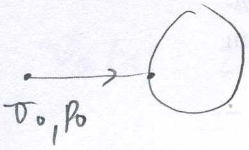
$v(x) = 2v_0 \cdot \sin(x/R)$



$dx = R\,d\theta$

$x = R.\theta$ ↑ rad.

a) Eq. Bernoulli: $P_0 + \frac{1}{2}\rho v_0^2 = P(x) + \frac{1}{2}\rho v^2(x)$



$$P_0 + \frac{1}{2}\rho v_0^2 = P(x) + \frac{1}{2}\rho \left[2v_0 \sin(x/R)\right]^2$$

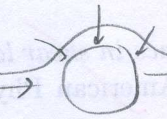
$$\Leftrightarrow P_0 + \frac{1}{2}\rho v_0^2 = P(x) + 2\rho v_0^2 \sin^2(x/R)$$

$$P(x) = \underbrace{P_0 + \frac{1}{2}\rho v_0^2}_{P_E} - 2\rho v_0^2 \sin^2(x/R)$$

$$P(x) = P_E - 2\rho v_0^2 \sin^2(x/R)$$

$$P(x) = P_0 + \frac{1}{2}\rho v_0^2 \left[1 - 2\sin^2(x/R)\right.$$

b) Eixo Simetria



Logo $D_p = 0$ $\quad \oint p(x)\,\vec{n}\,dS = 0$

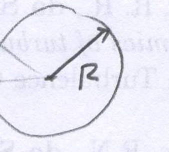
thwaites $\lambda(x) = \frac{\theta^2}{\nu}\frac{dU_\infty}{dx}$

&

[illegible] ocorre se $\lambda = -0,09$

$$\theta^2(x)\,U_\infty^6 = 0,45\nu\int_{0}^{x} U_\infty^5(x)\,dx \quad (\text{tomando } \theta_0 = 0 \text{ p/ } x = 0)$$

$$U_\infty(x) = 2U_0 \sin(x/R)$$



$dx = R\,d\theta$

$x = R.\theta$

donde

$$\theta^2(x) = \frac{0,45\nu}{\left[2U_0 \sin(x/R)\right]^6}\int_0^x 2U_0 \sin^5(x/R)\,dx$$

$$= \frac{0,45\nu}{2U_0 \sin^6(x/R)}\int_0^x \sin^5(x/R)\,dx$$

$\int \sin(ax)\,dx = -\frac{1}{a}\cos(ax) + C$

- - - -

$$\int_0^x \sin^5(x/R)\,dx = \left[-\frac{\sin^4(x/R)\cos(x/R)}{(5/R)}\right]_0^x + \frac{4}{5}\int_0^x \sin^3(x/R)\,dx$$

$$= -\frac{\sin^4(x/R)\cos(x/R)}{(5/R)} + \frac{4}{5}\left\{\left[-\frac{\sin^2(x/R)\cos(x/R)}{(3/R)}\right]_0^x + \frac{2}{3}\int_0^x \sin(x/R)\,dx\right\}$$

$$= -\frac{\sin^4(x/R)\cos(x/R)}{(5/R)} - \frac{4}{5}\,\frac{\sin^2(x/R)\cos(x/R)}{3/R} + \frac{2}{3}\Big[-R.\cos(x/R)\Big]_0^x$$

$$(x) = \frac{0,45\nu}{2v_0 \sin^6(x/R)} \left\{ \frac{-\sin^4(x/R)\cos(x/R)}{5/R} - \frac{4}{5}\frac{\sin^2(x/R)\cos(x/R)}{3/R} + \frac{2}{3}\left(-R\cos(\tfrac{x}{R})+R\right.\right.$$

$$\theta^2(x) = \frac{0,45\nu \cdot R}{2v_0\sin^6(x/R)}\left[-\frac{\sin^4(x/R)\cos(x/R)}{5} - \frac{4}{5}\frac{\sin^2(x/R)\cos(x/R)}{3} - \frac{2}{3}\cdot\left(\cos(\tfrac{x}{R})-1\right)\right]$$

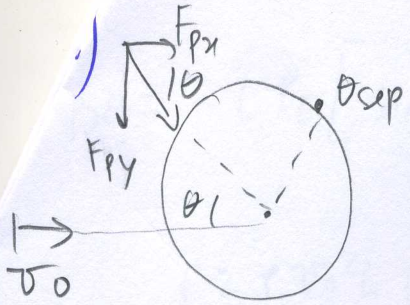
$$\frac{dv_\infty}{dx} = \frac{2v_0}{R}\cdot\cos(x/R)$$

[illegible] quando x_{sp} : $X(x_{sp}) = \frac{\theta^2(x_{sp})}{\nu}\cdot\left.\frac{dv_\infty}{dx}\right|_{x_{sp}} = -0,09$

$$\frac{0,45\cancel{\nu}\cdot \cancel{R}}{\cancel{2}\cancel{v_0}\sin^6(x/R)}\left[\frac{-\sin^4(x/R)\cos(x/R)}{5} - \frac{4}{5}\frac{\sin^2(x/R)\cos(x/R)}{3} - \frac{2}{3}\left(\cos(\tfrac{x}{R})-1\right)\right]\cdot\frac{\cancel{2}\cancel{v_0}}{\cancel{R}\cancel{\nu}}\cos(x/R) = -0,09$$

$$\frac{0,45}{\sin^6(x_{sp}/R)}\left[-\frac{\sin^4(x_{sp}/R)\cos(x_{sp}/R)}{5} - \frac{4}{5}\frac{\sin^2(x_{sp}/R)\cos(x_{sp}/R)}{3} - \frac{2}{3}\left(\cos(\tfrac{x_{sp}}{R})-1\right)\right]\cdot\cos(x_{sp}/R) = -0,09$$

função de x_{sp}, R only!



$$p(x) = p_E - 2\rho v_0^2 \sin^2(x/R)$$

$$ds = L\,dx = L.R\,d\theta$$

$$dx = R\,d\theta$$

$$\theta_{sep} = 104{,}5^0$$
$$= 1{,}823 \text{ rad}$$

$$\vec{F}_p = -\int p\,\vec{n}\,ds$$

$$p_x = p(x).\cos\theta$$

$$F_{px} = -\int p_x\,ds$$

$$F_{px} = -\int_0^{\theta_{sep}} L.p(x)\cos\theta.dx - \int_{\theta_{sep}}^{\pi} L.p_{sep}.\cos\theta.dx$$

$$= -\left[L\int_0^{\theta_{sep}} (p_E - 2\rho v_0^2 \sin^2(x/R)\cos\theta)\,dx + L\int_{\theta_{sep}}^{\pi} p_{sep}.\cos\theta\,dx\right]$$

$$= -L\left[\int_0^{\theta_{sep}} p_E.\cos\theta\,dx + \int_0^{\theta_{sep}} -2\rho v_0^2 \sin^2\theta\cos\theta\,dx + \int_{\theta_{sep}}^{\pi} p_{sep}.\cos\theta\,dx\right] =$$

$$= -L\,p_E\int_0^{\theta_{sep}} \cos\theta\,dx + 2\rho v_0^2 L\int_0^{\theta_{sep}} \sin^2\theta\cos\theta\,dx - p_{sep}L\int_{\theta_{sep}}^{\pi}\cos\theta\,dx$$

$$= -L\,p_E\left[\sin\theta\right]_0^{\theta_{sep}} + 2\rho v_0^2 L\left[\frac{\sin^3\theta}{3}\right]_0^{\theta_{sep}} - p_{sep}.L\left[\sin\theta\right]_{\theta_{sep}}^{\pi} =$$

$$p_x = -L\,p_E\left[\sin(\theta_{sep}) - 0\right]$$

$$\sin(\theta_{SEP}) = \sin(104{,}5^\circ) = \theta'$$

$$+\frac{2\rho v_0^2 L}{3}\left[\sin^3(\theta_{sep}) - 0\right]$$

$$-\;p_{SEP}\,L\left[0 - \sin\theta_{sep}\right]$$

$$= -L\,p_E\sin\theta' + \frac{2\rho v_0^2 L}{3}\sin^3\theta' + \left(p_E - 2\rho v_0^2\sin^2\theta'\right)\cdot L$$

$$= p_E\cdot L\left(1 - \sin\theta'\right) + \rho v_0^2\cdot L\left(\frac{2\sin^3\theta'}{3} - 2\sin^2\theta'\right)$$

$$p_{SEP} = p_E - 2\rho v_0^2\sin^2(\theta_{SEP})$$

$$C_D = \frac{D_{visc} + D_{inv}}{\frac{1}{2}\rho V_0^2 . L . D} \qquad D = D_{visc} + D_{inv.}$$

$$D_{inv} = F_p^x \quad \text{(já calculado)}$$

$$D_{visc} + D_{inv} = \frac{1}{2}\rho V_0^2 L . D \; C_D$$

$$D_{visc} = F_p^x - \frac{1}{2}\rho V_0^2 L D C_D$$

$$= P_E L\left(1 - \sin\theta'\right) + \rho V_0^2 L\left(\frac{2\sin^3\theta'}{3} - 2\sin^2\theta'\right) - \frac{1}{2}\rho V_0^2 L D \underset{1,2}{C_D}$$