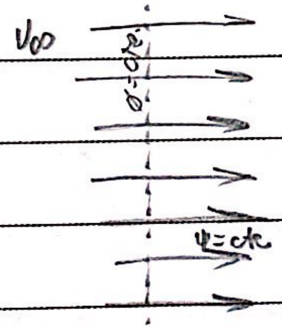
① Escoamento elementar Dipolo + uma corrente livre

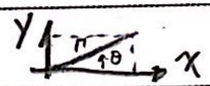
↳ ϕ, V_r, V_θ sobre cilindro sem Rotação?

Hipóteses:

- fluxo incompressível e irrotacional.

P/ um fluxo Uniforme de corrente livre, temos





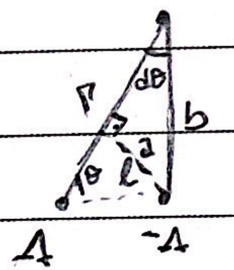
$$d\phi = V_\infty \, dx$$

$$\phi_1 = V_\infty \, r \cos\theta$$

$x = r \cdot \cos\theta$

$y = r \cdot \operatorname{sen}\theta$

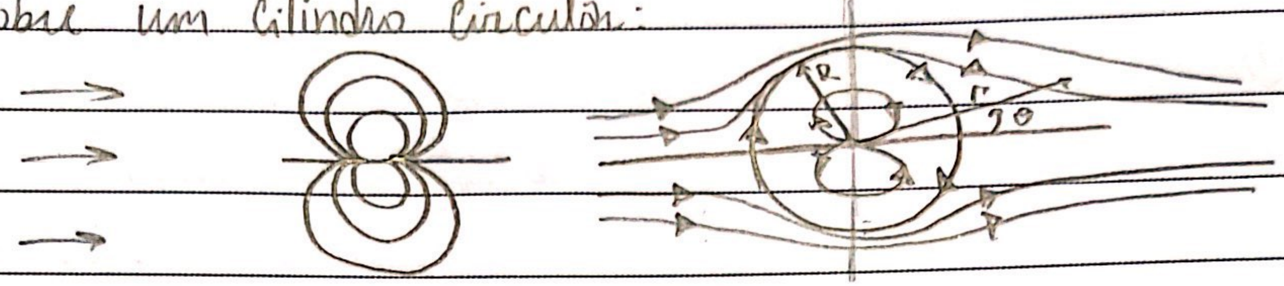
P/ um Dipolo, temos



$$\begin{cases} l \to 0 \\ l\Lambda = cte = K \end{cases}$$

$$\phi_2 = \frac{K}{2\pi} \frac{\cos\theta}{r}$$

A combinação (superposição) produz um escoamento sobre um cilindro circular:



$\phi_1 = V_\infty r \cos\theta$ $\quad \phi_2 = \frac{K}{2\pi} \frac{\cos\theta}{r}$ $\quad \phi = V_\infty r \cos\theta + \frac{K}{2\pi} \frac{\cos\theta}{r}$

$$\phi = V_\infty . r . \cos\theta \left(1 + \frac{K}{2\pi V_\infty . r^2} \right)$$

sendo $R^2 = \frac{K}{2\pi V_\infty}$

$$\phi = V_\infty . r \cos\theta \left(1 + \frac{R^2}{r^2} \right).$$

Logo

$$V_r = \frac{\partial \phi}{\partial r} = \frac{\partial}{\partial r} \left[V_\infty r \cos\theta + \frac{V_\infty R^2 \cos\theta}{r} \right]$$

$$V_\theta = \frac{1}{r} \frac{\partial \phi}{\partial \theta} = \frac{1}{r} \frac{\partial}{\partial \theta} \left(V_\infty . r . \cos\theta \cdot \left(1 + \frac{R^2}{r^2} \right) \right)$$

$$V_r = V_\infty \cos\theta - \frac{V_\infty R^2 \cos\theta}{r^2} = V_\infty \cos\theta \left(1 - \frac{R^2}{r^2}\right)$$

$$V_\theta = \frac{1}{\cancel{r}}\left[-V_\infty \cancel{r}\, \text{sen}\,\theta \left(1 + \frac{R^2}{r^2}\right)\right]$$

$$V_\theta = -V_\infty \,\text{sen}\,\theta \left(1 + \frac{R^2}{r^2}\right)$$