MEHANIKA FLUIDOV

TLAK

$\Delta p = \rho \cdot g \cdot \Delta h$

$p^n = p - p_0$

$p^p = p_0 - p$

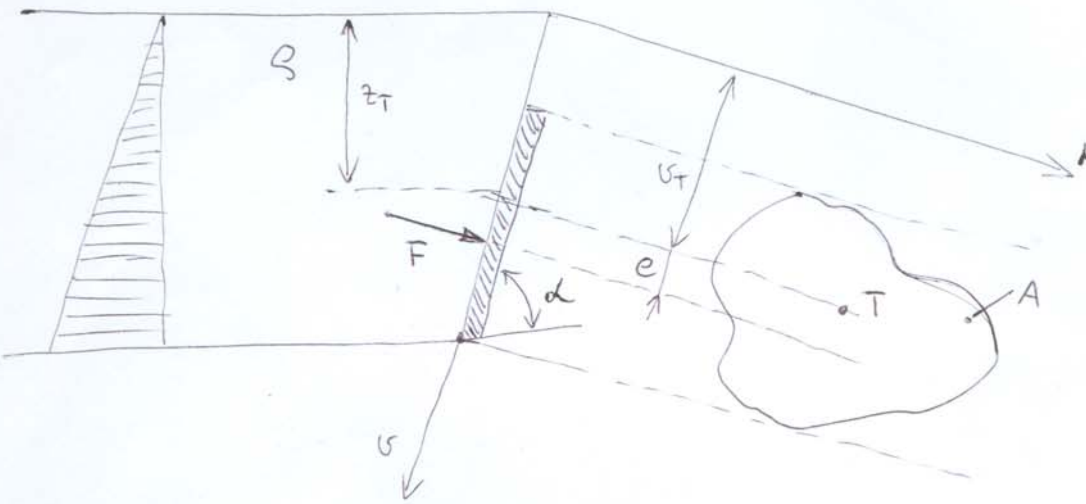
$p^n = -p^p$

stisljivost pri velikih tlakih:

$$\rho(h) = \frac{E \cdot \rho_0}{E - \rho_0 \cdot g \cdot h}$$

$$\Delta p = E \cdot \ln\left(\frac{E}{E - \rho_0 \cdot g \cdot h}\right)$$

ZAPORNICE



$F = \rho \cdot g \cdot z_T \cdot A$

$e = \frac{I_{ut}}{u_T \cdot A} > \emptyset$

$I_{ut} \Rightarrow$ KSP 116

če je v posodi nadtlak:

$H^* = \frac{p^n}{\rho \cdot g}$

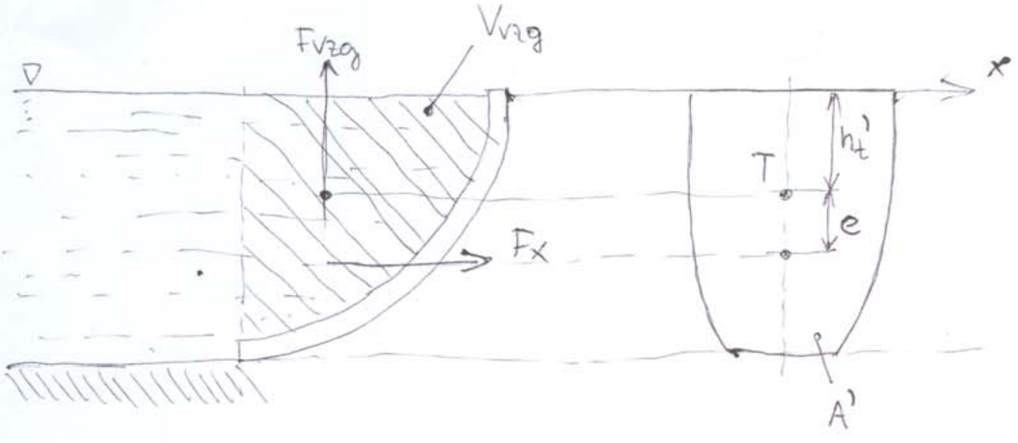
SILA NA POTOPLJENO UKRIVLJENO PLOSKEV

VZGON

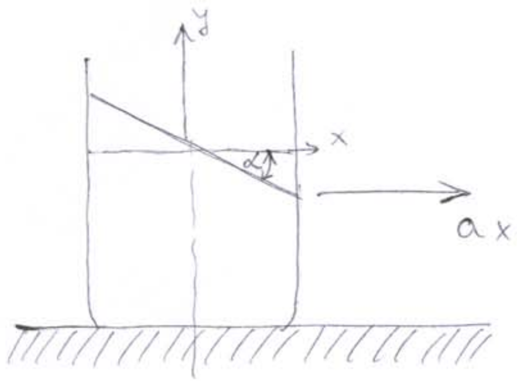
$F_{vzg} = \rho \cdot g \cdot V_{vzg}$

$F_x = \rho \cdot g \cdot h_t' \cdot A'$

$e = \frac{I_{x_T'}}{A' \cdot h_t'}$



RELATIVNO MIROVANJE



$$\tan\alpha = -\frac{a_x}{g+a_y}$$

$$y = -\frac{a_x}{g+a_y}\cdot x + y_0$$

$$\frac{\partial p}{\partial x} = -\rho\cdot a_x \qquad \frac{\partial p}{\partial y} = -\rho\cdot(g+a_y)$$

$$p(x,y) = -\rho\cdot a_x\cdot x - \rho(a_y+g)\cdot y$$

SILA NA KOLENO

$$R = \underbrace{\sum_i^n p_i n_i A_i}_{\text{za odprte tokove } = \emptyset} + \sum_i \rho\cdot\vec{v}_i(\vec{v}_i\vec{n}_i)A_i \underbrace{- m\cdot g}_{y:\ \oplus\ (\ominus\cdot\ominus)}$$

$$F = -\vec{R} = (-R_x, -R_y)$$

$$R_x = Q\cdot\rho(v_1\cos\alpha_1 - v_2\cos\alpha_2) + \overbrace{p_1A_1\cos\alpha_1 - p_2A_2\cos\alpha_2}^{\text{za odprte tokove } = \emptyset}$$

$$R_y = Q\cdot\rho(v_1\sin\alpha_1 - v_2\sin\alpha_2) + p_1A_1\sin\alpha_1 - p_2A_2\sin\alpha_2$$

KONTINUITETNA ENAČBA

ZAKON O OHRANITVI MASE

$$Q = \text{konst.}:\quad v_1A_1 = v_2A_2$$

$$\dot{m} = \rho\cdot Q$$

IMPULZNI STAVEK

ZAKON O OHRANITVI GIBALNE KOLIČINE

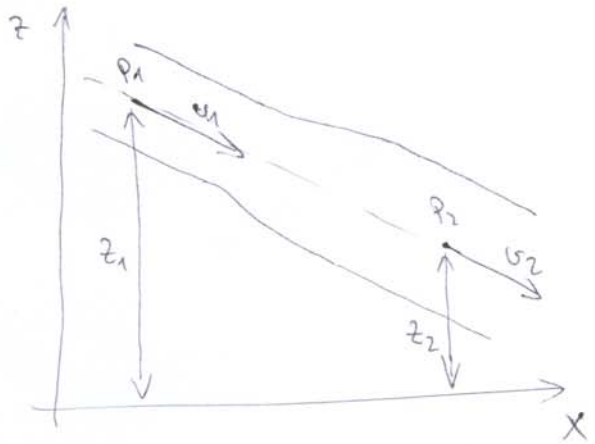
$$\vec{G} = \int_V \rho\cdot\vec{v}\,dV$$

masne sile zanemarimo

$$R = \int_V \cancel{\frac{\partial(\rho\cdot\vec{v})}{\partial t}}^{=\emptyset} dV + \int_A p\cdot\vec{n}\,dA + \int_A \rho\cdot\vec{v}(\vec{v}\cdot\vec{n})\,dA - \cancel{\int_V \rho\cdot f_m\,dV}$$

BERNOULIJEVA ENAČBA

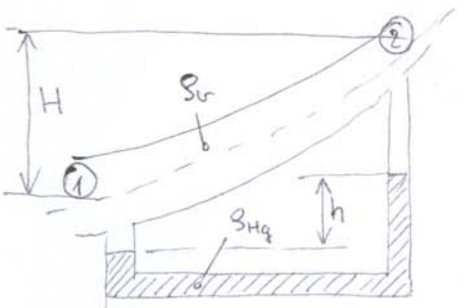
ZAKON O OHRANITVI ENERGIJE



$$\frac{v_1^2}{2g} + \frac{p_1}{\rho \cdot g} + z_1 = \frac{v_2^2}{2g} + \frac{p_2}{\rho \cdot g} + z_2$$

če je $p < 0 \rightarrow v = 0$ (NE TEČE)

POTREBNO JE CEV SKRAJŠATI



$$p_2^n = p_1^n - \rho_v \cdot g \cdot H - (\rho_{Hg} - \rho_v) \cdot g \cdot h$$

KINEMATIKA FLUIDOV

KONTINUITETNA ENAČBA → NESTISLJIVOST!

$\rho = \text{konst.}$ $\quad div(\vec{v}) = 0 = \left(\frac{\partial v_x}{\partial x}, \frac{\partial v_y}{\partial y}, \frac{\partial v_z}{\partial z}\right)$ $\qquad div(\vec{v}) = \nabla \vec{v} = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y}$

$$\frac{\partial \rho}{\partial t} + div(\rho \cdot \vec{v}) = 0$$

$$\boxed{\begin{aligned}
\vec{a} &= \frac{d\vec{v}}{dt} = \frac{\partial \vec{v}}{\partial t} + \frac{\partial \vec{v}}{\partial x} v_x + \frac{\partial \vec{v}}{\partial y} v_y + \frac{\partial \vec{v}}{\partial z} v_z \\
a_x &= \frac{dv_x}{dt} = \frac{\partial v_x}{\partial x} v_x + \frac{\partial v_x}{\partial y} v_y + \frac{\partial v_x}{\partial z} v_z + \frac{\partial v_x}{\partial t} \\
a_y &= \frac{dv_y}{dt} = \frac{\partial v_y}{\partial x} v_x + \frac{\partial v_y}{\partial y} v_y + \frac{\partial v_y}{\partial z} v_z + \frac{\partial v_y}{\partial t} \\
a_z &= \frac{dv_z}{dt} = \frac{\partial v_z}{\partial x} v_x + \frac{\partial v_z}{\partial y} v_y + \frac{\partial v_z}{\partial z} v_z + \frac{\partial v_z}{\partial t}
\end{aligned}}$$

ENAČBA TOKOVNIC:

$$\frac{dy}{v_y} = \frac{dx}{v_x} = \frac{dz}{v_z}$$

VRTINČNOST

$$w = \frac{1}{2} |rot(\vec{v})| \quad , \quad rot(\vec{v}) = \vec{k} \left(\frac{\partial v_y}{\partial x} - \frac{\partial v_x}{\partial y}\right)$$

če je tok ravninski, je rotor pravokoten na ravnino (ni vrtincev):

$$rot(\vec{v}) = 0$$

KOMPLEKSNI TOKOVI

$\vec{v} = (v_x, v_y)$

$\tilde{v} = v_x - i \cdot v_y$ → KOMPLEKSNA HITROST

$\tilde{f} = \varphi + i \cdot \psi$ → KOMPLEKSNI POTENCIAL

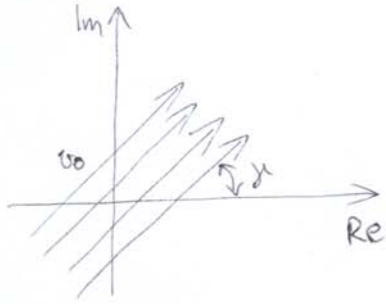
$z = x + i \cdot y = r(\cos\alpha + i \cdot \sin\alpha) = r \cdot e^{i \cdot \alpha}$

$\tilde{v} = \tilde{v}_1 + \tilde{v}_2 + \ldots$

$\tilde{f} = \tilde{f}_1 + \tilde{f}_2 + \ldots$

$$\boxed{\frac{1}{z - z_0} = \frac{1}{(x-x_0) + i(y-y_0)} = \frac{(x-x_0) - i(y-y_0)}{(x-x_0)^2 + (y-y_0)^2}}$$

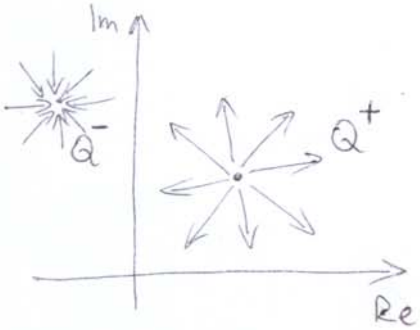
PARALELNI TOK:



$\tilde{f} = v_0 \cdot z \cdot e^{i \cdot \gamma}$

$\tilde{v} = v_0 \cdot e^{-i \cdot \gamma} = v_0 (\cos\gamma - i \cdot \sin\gamma)$

IZVOR ALI PONOR:



(+) IZVOR

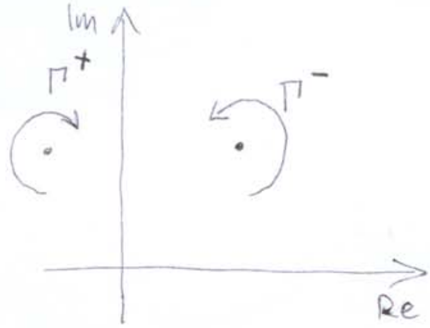
(−) PONOR

$Q > 0$

$\tilde{f} = \pm \frac{Q}{2\pi} \cdot \ln(z - z_0)$

$\tilde{v} = \pm \frac{Q}{2\pi} \cdot \frac{1}{z - z_0}$

CIRKULACIJA:



$\Gamma > 0$

$\tilde{f} = \mp \frac{i \cdot \Gamma}{2\pi} \ln(z - z_0)$

$\tilde{v} = \mp \frac{i \cdot \Gamma}{2\pi} \cdot \frac{1}{z - z_0}$

DOLOČITEV OBLIKE TELESA:

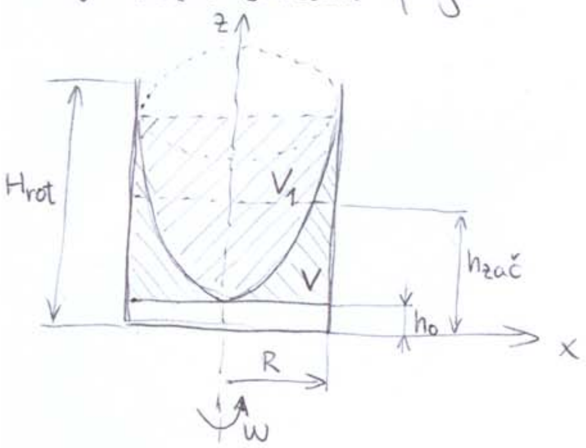
- zastopna točka ($\tilde{v} = 0, v_x = 0, v_y = 0$)
- kompleksni potencial $\tilde{f}$
- rešitev je Im del ψ = konst.
- robni pogoj z.t. ($z = \ldots \to r, \alpha$)
- ψ z r in α → konst.
  (REŠITEV = konst.)

TLAK IN HITROST V NESKONČNOSTI:

$$\frac{\rho \cdot v_A^2}{2} + p_A = \frac{\rho \cdot v_\infty^2}{2} + p_\infty$$

ROTACIJA POSOD

Nestisljiva kapljevina pri enakomerni rotaciji okrog vertikalne osi v težnostnem polju:



$a_n = -w^2 \cdot R$

$V = V_1$

$w = 2\pi \cdot n$

$z_1 = \frac{w^2}{2g} r_1^2$

$z_2 = \frac{w^2}{2g} r_2^2$

ENAČBA GLADINE:

$$\frac{w^2(x^2+y^2)}{2} + g(h_0 - z) = \emptyset \quad , \quad x^2+y^2 = R^2$$

$$\frac{w^2}{2} \cdot R^2 + g(h_0 - z) = \emptyset$$

- volumen kapljevine pri mirovanju $V = \pi R^2 \cdot h_{zač}$
- volumen rotacijskega paraboloida $V_1 = \frac{\pi}{2} R^2 (H_{rot} - h_0)$
- volumen kapljevine pri enako. rotaciji $V = \pi R^2 \cdot H_{rot} - V_1$

$$H_{rot} - h_{zač} = \frac{1}{2}(H_{rot} - h_0)$$

ZAPRTA POSODA

$r_p^2 = \frac{2gH}{w^2}$ → velja, ko je rot. posoda zaprta in bi, če bi bila odprta, tekočina stekla ven

r_p = polmer rot. paraboloida

$R_2 = R\sqrt{\frac{2(H-h)}{H}}$ → radij kroga, ki ga voda ne pokriva na pokrovu posode

$w_D = \frac{1}{R_2}\sqrt{2gH} = \frac{H}{R}\sqrt{\frac{g}{H-h}}$ → pri tej w se prikaže dno pri rotaciji.

ODPRTA POSODA

$w_{pre} = \frac{2}{R}\sqrt{g(H-h)}$ → w pri kateri začne tekočina iztekati ven

$w_{DNA} = \frac{2}{3}\sqrt{gH}$ → w pri kateri se gladina dotakne dna

PORAZDELITEV TLAKA V TEKOČINI

$$p - p_0 = \frac{\rho}{2}(w^2 r^2 - 2g \cdot z)$$

ČRPALKE

$$\frac{v_0^2}{2g} + \frac{p_0^{(n)}}{\rho g} + z_0 = \frac{v_1^2}{2g} + \frac{p_1^{(n)}}{\rho g} + z_1 + h_{izg} - H_č \quad , \quad H_č = H + h_{izg} = \frac{\Delta p}{\rho g}$$

$= \emptyset$ (če črpalke ni na poti)

količnik lin. izgub

$$h_{izg} = \frac{v^2}{2g}\left(\xi_{lok} + \xi_{lin}\right)$$

KOLENA!

$x \cdot \xi_k + y \cdot \xi_{st} \dots$

$\xi_{lin} = \lambda \cdot \frac{l}{d}$

$\varepsilon = k$, KSP, str. 143

$$Re = \frac{v \cdot d_h}{\nu} \quad , \quad d_h = \frac{4A}{O} \quad , \quad v = \frac{Q}{A}$$

$\nu = 14{,}9 \cdot 10^{-6}\ m^2/s$ ZRAK

$\nu = 1{,}5 \cdot 10^{-6}\ m^2/s$ VODA

$Re < 2320$ → LAMINAREN

$Re < 2320$ → TURBOLENTEN

TURBOLENTEN TOK:

$$\lambda = \frac{0{,}309}{\left[\log(0{,}143 \cdot Re)\right]^2} \quad (\varepsilon = \emptyset)$$

$$\lambda = \frac{0{,}25}{\left[\log\left(\frac{15}{Re} + 0{,}269\,\frac{\varepsilon}{d}\right)\right]^2} \quad (\varepsilon \neq \emptyset)$$

ln''

ln''

MOČ ČRPALKE:

$$P_č = \frac{\rho \cdot v \cdot \pi d^2 H_č \cdot g}{4 \cdot \eta_č} = \Delta p_č \frac{Q}{\eta_č} = \frac{Q \cdot g \cdot H_č}{\eta}$$